POWER

Vol. 40 NEW YORK, AUGUST 25, 1914 No. 8

Fools

By R. T. Strohm

Gone is the epoch of dark superstitiousness;
Wisdom and reason have put it to flight.
Almost forgot are its folly and viciousness,
Faded and dim as a dream of the night.
Far have we journeyed and fast are we traveling,
Leaving Old Ignorance bogged in his tracks,
Yet there is room for complaining and caviling;
Still there is work for the fool-killer's ax.

Though we are wondrously wise in these latter days,
Cynics will criticize, snicker and smirk,
Reading of boilers, with fires banked Saturdays,
Bursting on Mondays when put to their work.
Maybe it chanced through a fireman's blundering;
Maybe inspection was lacking or lax;
Yet we are prone to a natural wondering
Whether there's work for the fool-killer's ax.

Spite of all efforts in lines educational,
Spent upon every condition and rank,
Some one, unconsciously growing sensational,
Opens the blow-off valve wide with a yank.
Elsewise some idiot, while his superior
Seeks in a boiler for pitting and cracks,
Opens a steam valve and fills the interior,
Yes, there is work for the fool-killer's ax.

Still we are cursed by some absolute dunderpate
Loading the safety-valve lever with junk,
Letting the scale collect, burning the under plate,
Courting disaster by working while drunk.
Round up these rogues who are acting so fearfully;
Bind them securely, their hands at their backs;
Send for the headsman and bid him come cheerfully,
Here is good work for the fool-killer's ax.

Power Plant at Hillsboro, Ill.

By Thomas Wilson

SYNOPSIS—A 1750-kw. condensing plant furnishing current for street and residence lighting, power and street-railway service, exhaust steam for heating and making ice, besides pumping the city water.

At the town of Hillsboro, Ill., which has a population of 7500, are located the offices and the main plant of the Southern Illinois Light & Power Co. The plant is interesting, as it supplies seven different services in the home town and current to a number of surrounding towns. There are 90 miles of transmission lines connecting the various substations, and where heating is also required, prime movers are installed to operate in parallel with the main station. Three-phase, 60-cycle current is generated, and for transmission to distant substations is stepped up to 16,500 and 33,000 volts. In each of these towns the arc and residence lighting and power demands are supplied. The street-railway load consists of the Hillsboro and Taylor Spring lines, and besides current is fed into the McKinley system. Exhaust steam at 5-lb. pressure heats the business district of Hillsboro, and from 5,000,000 to 10,000,000 gal. per month of city water is pumped at the station. It may be of interest to learn that a correspondence school student, Jesse L. Best, while completing his studies, was directly responsible for the layout of the station to J. J. Frey, president and general manager of the company. He had charge of the installation of the machinery and is now chief engineer. As soon as time permitted, he worked up an excellent system of records, so that it was possible to divide the total costs between the various services of the plant.

Briefly, the equipment consists of 1144 hp. in four water-tube boilers, although in the very near future two 400-hp. boilers will be added. In the engine room there is capacity to generate 1750 kw., which reduces to 1.53 kw. per hp. of boiler rating. With the new boilers installed, the ratio will drop to 0.9. For the generating capacity of the station, the boiler power is high, but of course steam is required for a 25-ton absorption refrigerating plant. During the heating season live steam is used occasionally, and during the colder months steam-driven pumps supply the city water. There is also a probability of installing additional generators as the load is constantly increasing.

Fig. 1. Hillsboro Station of the Southern Illinois Light & Power Co.

The building, Fig. 1, is a two-story brick structure, 76x140 ft., equipped with fireproof doors. The boiler and engine rooms are located at the stack end of the building, the boiler-room floor being on a level with the basement under the engine room. In the latter are located the condensers and some of the pumps, while at the opposite end of the building is the ice-making plant. At the right is a new transformer house and at the left is a large cooling tower, as in this territory the supply of water is limited.

Boiler Room

As intimated previously, there are four 286-hp. water-tube boilers, with provision for the early installation of two more rated at 400 hp. each. The operating pressure

is 165-lb. gage. Each boiler is equipped with a shaking grate, 7 ft. 3 in. long and 8 ft. 6 in. wide, set 3 in. lower at the rear end. Provision was also made for stoker settings, and at the present writing, work is under way to install chain grates. In each boiler there are 2858 sq.ft. of heating surface and its ratio to the total surface in the grate is 46.4 to 1. The effective surface in the grate would, of course, be less, so that the true ratio would probably reach the conventional 50 to 1.

At the stack the breeching measures 5 ft. 8 in. by 10 ft. 6 in. and gradually tapers toward the last boiler. The stack is of reinforced concrete, offset type, 8 ft. in diameter and 150 ft. high. Consequently, the breeching area is 59.5 sq.ft. to 50.26 sq.ft. in the stack. For every square foot of breeching area there are 4.1 sq.ft. of connected grate, and for 1 sq.ft. of stack area, 4.9 sq.ft. of grate. Per horsepower of boiler rating the stack has a sectional area of 0.044 sq.ft., or 6¼ sq.in. These figures run close to average practice. Illinois screenings, 1½-in. Hillsboro, is the fuel burned. The draft at the base of the stack runs close to 0.7 in., and over the fire it averages from 0.2 to 0.45 in., depending on the thickness of the fuel bed and the condition of the fires.

The boilers are provided with feed-water regulators, and a water meter measures the supply. Three-tier permanent platforms give access for blowing and cleaning the tubes. The blowing is done by steam every 24 hr., while the hard deposit in the tubes is removed by a turbine cleaner driven by air compressed to 60 lb. pressure by a locomotive type compound air compressor mounted on the engine-room wall. From each boiler, a 7-in. pipe leads to a 10-in. header containing an angle valve and an automatic stop and check valve.

Water for feed purposes is drawn from a creek ¼ mile distant through a twin filter and is delivered to a 1000-hp. open heater which receives the exhaust from the pumps. Duplicate feed pumps of the duplex outside center-packed type, 10 and 5½ by 10 in., are installed and are controlled by pump governors.

The coal at present is dumped directly from railway cars into a 20x88-ft., 600-ton bin at the side of the boiler room. Through doors at the bottom of the bin it is delivered onto the boiler room floor and hand-fired into the furnaces. The plant is on the side of a hill, so that the elevation of the ground makes this arrangement possible. When the stokers are installed, automatic delivery to their hoppers is contemplated, but the method is still open to decision.

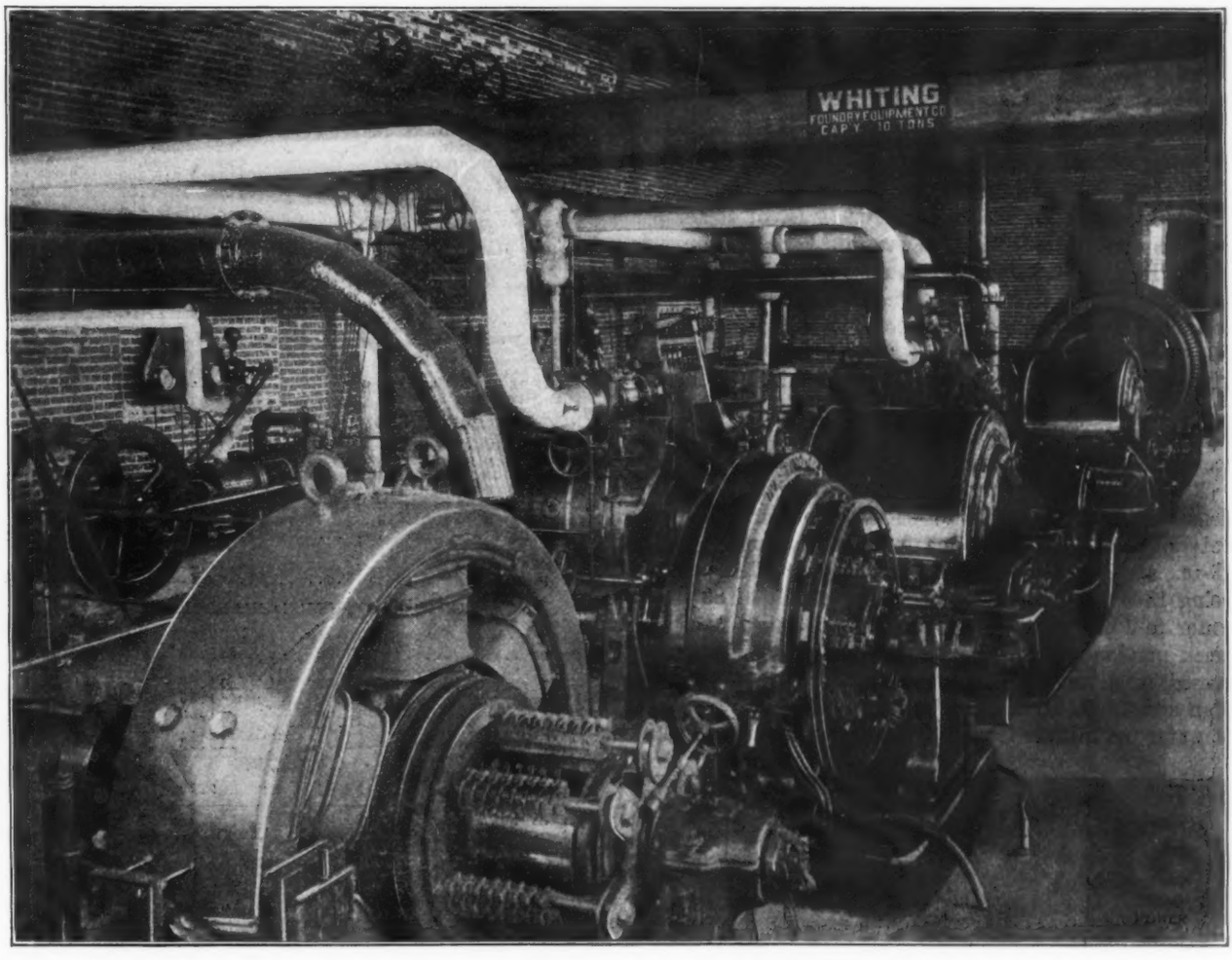


FIG. 2. THE TURBINE ROOM OF THE PLANT

ENGINE ROOM

In this department, shown in Fig. 2, the main generating units are two 750-kw. two-stage impulse turbines driving three-phase, 60-cycle generators at a speed of 3600 r.p.m. There is also a 250-kw. alternator driven at

200 r.p.m. by a simple noncondensing 20x20-in. engine. This unit is run mostly during the heating season to supply exhaust steam at 5-lb. pressure. The electrical load is varied to suit the demand for steam, and the balance, which is the greater part of the output, is carried by one of the turbo-generators, operated condensing at an average vacuum of 28½ in. The two machines operate in parallel. The turbines are of the bleeder type; that is, provision has been made to draw off steam between the stages at 5-lb. pressure for the heating. The engine and pumps, however, have supplied enough exhaust steam so that there has been no occasion to call on the turbines. The condensers are of the surface type, each containing 2600 sq.ft. of surface, or 3.47 sq.ft. per kw. of turbine rating. At full load and 28½ in. of vacuum, the turbines will develop a kilowatt-hour on 19 lb. of dry saturated steam, so that at full load there will be an hourly discharge to the condenser of

$$750 \times 19 \times 0.77 = 10{,}972 \ lb.$$

of steam. Of this, each square foot of surface must condense 4.22 lb. The turbine exhaust to the condenser is 30 in. in diameter, and to pass 10,972 lb. of steam per hour, equivalent to 182.87 lb. per min., or at a pressure of 0.7 lb. abs. 85,821 cu.ft., would necessitate a velocity of nearly 17,500 ft. per min. The live steam supply pipe to each turbine has a diameter of 4½ in. and an rea of 15.947 sq.in., which amounts to 0.0212 sq.in. per kw. of turbine rating as compared to 0.94 sq.in. for the exhaust. Passing 182.87 lb. per min. of dry saturated steam at 165 lb. gage through this pipe calls for a velocity of 4191, or practically 5000 ft. per min.

For the condensers the circulating water and the condensation are handled by centrifugal pumps. Each circulating pump (there is one for each condenser) has a 10-in. suction and an 8-in. discharge. The capacity being 1800 gal. per min. permits the supply of 82 lb. of water to 1 lb. of steam. The supply is taken from the creek previously mentioned, and from the condensers is passed to a natural draft cooling tower 44x55 ft. in plan and 76 ft. high. It is guaranteed to cool 2800 gal. of water per minute from 106½ to 85 deg. when the outside temperature is 75 deg. and the humidity 70 per cent.

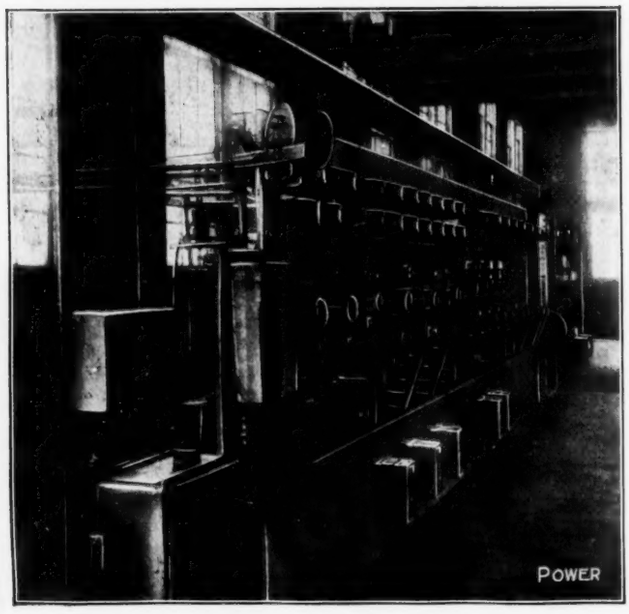


FIG. 3. VIEW OF THE SWITCHBOARD

Condensate from the condensers is discharged by 2-in. two-stage turbine-driven pumps to a 10,000-gal. distilled water tank. A small part of this water is drawn off for ice making and the balance is boiler feed. The dry-vacuum pumps are of the reciprocating crank and flywheel type dimensioned 10x16x10 in.

All steam-driven auxiliaries and the engine exhaust into a 12-in. main at a level lower than the engine-room floor, and for an emergency atmospheric exhaust the turbines are also connected to this main. At one end is the heater and the atmospheric exhaust, and at the other end the main, reducing to 10 in., continues to the business district, where it supplies exhaust steam at 5 lb. pressure to 25,276 sq.ft. of radiation. The condensation from this surface is trapped to the sewer and not returned to the plant, as in some cases.

MONTHLY REPORT OF MAIN GENERATING STATION AT HILLSBORO

	January, 1914	May, 1914
Coal consumed, lb.	2,729,900	2,380,900
Water evaporated, approx., lb.	15,000,000	13,518,000
Water evaporated per lb. coal, lb.	6.5	5.68
Kw.-hr. generated	228,630	291,288
Kw.-hr. delivered	210,840	261,961
Kw.-hr. used in station	16,590	28,144
Kw.-hr. used in ice plant	1,200	1,183
Ice pulled, lb.	72,450	738,900
Coal for ice, lb.	30,000	170,000
Steam for ice, lb.	180,000	769,000
Coal for steam heat, lb.	200,000	None
Steam for steam heat, lb.	4,000,000	None
Coal for pumping, lb.	158,000	180,000
Coal for electric service, lb.	1,915,800	2,025,900
Coal per kw.-hr.	8.37	6.95
Ice per ton of coal, tons	2.4	4.34
City water pumped, gal.	7,185,225	5,060,375
Power used	None	None
Coal for storage, lb.	410,100	None
Gas-plant coal, lb.	None	5,000
Coal sold, lb.	16,000	None

COSTS OF PRODUCTION, ELECTRIC

Station wages	$472.62
Coal:	
Cost	718.46
Freight and drayage	84.50
Handling	142.10
Water	.....
Lubricants, waste	20.75
Supplies and expense	13.90
Maintenance of boilers	44.27
Maintenance of engines	24.33
Maintenance of electric apparatus	1.30
Maintenance of miscellaneous station equipment	34.74
Maintenance of buildings	.....
Power in station	215.67
Total costs	$1772.64
Cost per kw.-hr.	0.0077

COSTS IN OTHER DEPARTMENTS

	Steam Heat	Ice Dept.	City Pumping
Wages	$43.00	$13.90	$36.00
Coal:			
Cost	75.00	11.25	59.25
Freight and dray.	8.00	1.35	6.50
Handling	12.00	1.80	9.48
Power	10.80	.....	.....
Supplies and expense	.....	128.22	.....
Maintenance miscellaneous station equipment	28.04	9.20	5.00
Total costs	$176.84	$165.72	$116.23
Cost per unit	4.4c. per M. lb.	$4.57 per ton	$0.016 per M. gal.

To supply 600-volt direct current for street-railway service there are two rotary converters, one 200 kw. and the other 300 kw. There are two 35-kw. exciters, one motor-driven and the other driven by a steam turbine. The latter is seldom used. The switchboard, Fig. 3, is of standard design, equipped with hand-operated oil switches, the latest instruments, a synchroscope and a Tirrell voltage regulator.

For pumping the city water, two duplex steam pumps, 14 and 8½ by 10 in., are installed. These pumps work against a head of 175 to 185 ft., and are used mostly in the winter months when exhaust steam is needed for heat-

ing. At other times the water is supplied by a 5-in. two-stage turbine pump driven by a three-phase 50-hp. motor. A 6-in. turbine meter measures the supply to the city.

As previously stated, the ice-making plant is of the absorption type, the capacity being 25 tons. The part of the equipment located in the basement is shown in Fig. 4. Exhaust steam from the brine, distilled-water and aqua pumps is usually sufficient to carry the load, which is light in winter due to small storage, and up to full capacity in the summer months. The ice is made in 300-lb. cans, of which there are 357, and the time of freezing is 52 hr. The condenser is of the double-pipe type having 1½ and 2½-in. pipe. To conserve the water supply to the condenser, it is passed through a forced-draft tower having a capacity of 300 gal. per min. The tower is 10 ft. in diameter and 34 ft. high. An 8-ft. disk fan driven by a 15-hp. belted motor creates the draft.

Costs of Production

From the preceding, a fair idea will be obtained of the plant equipment, and the monthly report shows what this equipment has been doing. The operating data for the months of January and May of 1914 are given, but

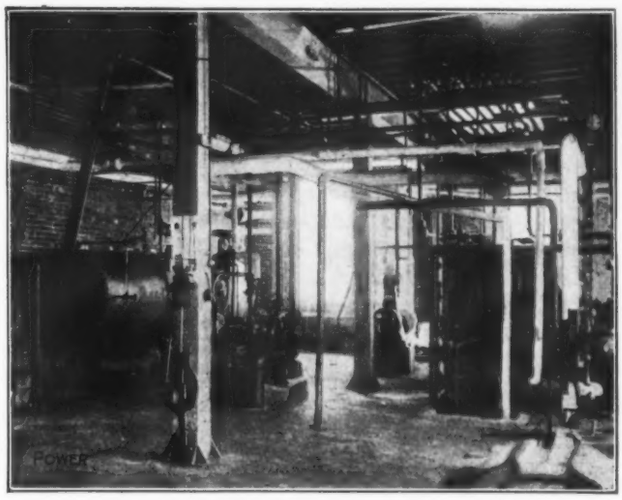


Fig. 4. Part of the Refrigerating System

PRINCIPAL EQUIPMENT OF HILLSBORO POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling-Class Q	286 hp.	Generate steam	165 lb. gage, natural draft, hand fired	Babcock & Wilcox Co.
4	Grates	"Treadkill" shaking grate	7 ft. 3 in. x 8 ft. 6 in.	Boiler furnace	Draft 0.7 in. base of stack, 0.35 in. over fire	H. M. Treadwell Co.
1	Chimney	Concrete, offset type	150 ft. high, 8 ft. dia.	Natural draft for boilers		Weber Chimney Co.
4	Feed water regulators	Turbine		Water level in boilers		Liberty Mfg. Co.
1	Strainer	Elliott	3-in. pipe con.	Strain water to plant		Elliott Co.
2	Pumps	Duplex, outside packed	10x5x10-in.	Water to boilers	Steam 165 lb. gage, head 400 ft.	Henry R. Worthington
2	Pump governors	Elliott		Regulate feed pumps		Elliott Co.
1	Feed-water heater	Open	1000 hp.	Heat feed-water	Exhaust steam	Harrison Safety Boiler Works
1	Pump	Direct-acting	7x6x10-in.	Distilled water to ice cans	Steam 165 lb. gage	National Foundry & Machine Co.
2	Pumps	Duplex	14x8½x10-in.	Pump city water	Steam 165 lb. gage, head 185 ft.	Henry R. Worthington
1	Pump	Turbine two-stage	5-in.	Pump city water	Motor-driven, capacity 600 gal. per min.	Alberger Pump & Condenser Co.
1	Motor	Alternating-current	50 hp.	Drive city-water pump	220 volt, three-phase, 1730 r.p.m.	Wagner Electric Mfg. Co.
2	Turbines	Impulse two-stage	750 kw.	Main unit	Saturated steam 165 lb. gage, 3600 r.p.m.	General Electric Co.
2	Generators	Alternating current	750 kw.	Main unit	Three-phase, 60-cycle, 2300 volt, 3600 r.p.m.	General Electric Co.
2	Condensers	Surface	2600 sq.ft.	For turbine units	28½ in. vac., 1800 gal. of water per min.	Henry R. Worthington
2	Pumps	Volute	10-in. suc., 8-in. dis	Condenser circulating water	600 to 1165 r.p.m.	Henry R. Worthington
2	Motors	Alternating-current	15 hp.	Drive circulating pumps	600 to 1165 r.p.m.	Wagner Electric Mfg. Co.
2	Pumps	Turbine	2-in., 2-stage	Condensate	Turbine driven, 1550 r.p.m.	Henry R. Worthington
2	Turbines	Impulse single-stage	5 hp.	Drive condensate pumps	Steam 165 lb. gage, 1550 r.p.m.	Terry Steam Turbine Co.
2	Pumps	Dry vacuum	10×16x10-in.	Air from condensers	Steam 165 lb. gage	Henry R. Worthington
1	Engine	Simple noncondensing	20x20-in.	Main unit	Steam 165 lb. gage, 200 r.p.m.	Chuse Engine & Mfg. Co.
1	Generator	Alternating-current	250 kw.	Main unit	Three-phase, 60-cycle, 2300 volt, 200 r.p.m.	Western Electric Co.
1	Rotary converter		200 kw.	Direct current for St. Ry.	2300-volt a.c. to 600 volt d.c.	Westinghouse Electric & Mfg. Co.
1	Rotary converter		300 kw.	Direct current for St. Ry.	2300-volt a.c. to 600 volt d.c.	General Electric Co.
1	Exciter		35 kw.	Excitation for main units	Motor-driven, 1200 r.p.m.	General Electric Co.
1	Exciter		35 kw.	Excitation for main units	Turbine-driven, 3600 r.p.m.	General Electric Co.
1	Crane	Traveling	10-ton	In engine room	Motor driven	Whiting Foundry Equipment Co
1	Cooling tower	Natural draft	44x55x76 ft.	Cool condensing water		Wheeler Condenser & Engineering Co. Carbondale Machine Co.
1	Refrigerating system	Absorption	25 ton	Making ice	Exhaust steam, brine, time of freezing 52 hr.	Henry Vogt Machine Co.
1	Pump	Volute	4-in.	Water for ammonia condenser	Turbine driven, 2500 r.p.m.	Jeanesville Iron Works Co.
1	Turbine	Single-stage impulse	10 hp.	Drive circulating pump	Steam 165 lb. gage, 2500 r.p.m.	Terry Steam Turbine Co.
1	Pump	Centrifugal	3-in.	Circulate brine	Motor driven, 180 gal. per min., 1750 r.p.m.	Jeanesville Iron Works Co.
1	Motor	Single-phase	5 hp.	Drive brine pump	220-volt, 1750 r.p.m.	Wagner Electric Mfg. Co.
1	Pump	Centrifugal	3-in.	Circulate brine	Motor driven, 200 gal. per min., 1165 r.p.m.	Jeanesville Iron Works Co.
1	Motor	Single-phase	2 hp.	Drive brine pump	220 volt, 1165 r.p.m.	Wagner Electric Mfg. Co.
1	Pump	Simplex	10x5x12-in.	Aqua pump	Steam 165 lb. gage	Carbondale Machine Co.
1	Cooling tower	Forced draft	10x34-ft., 300 gal. per min.	Cool water from ammonia condenser		Ruemmeli-Dawley Mfg. Co.
1	Fan	Disk type	8 ft. dia.	Draft for cooling tower	Belted to motor, 250 r.p.m.	Fairbanks Morse & Co.
1	Motor	Three-phase	15 hp.	Drive fan	220-volt, 1165 r.p.m.	Fairbanks Morse & Co.
1	Air compressor	Compound locomotive type	Steam 10½x16½x12 Air 9½x14½x12	Compressed air for boiler tube cleaner, etc.	Steam 165 lb. gage, air 60 lb.	Westinghouse Air Brake Co.

the costs per unit for the various services are available for only the first month in the year. Glancing over the figures it will be seen that the records are not as good as might be expected from an uptodate plant, but an analysis will show the reason. The coal, which is Illinois screenings averaging about 10,000 B.t.u., was hand fired, and as the boilers were operated under fluctuating loads, the evaporation ranged from 5.68 to 6.5 lb. of water per pound of coal. This same fluctuating load, caused largely by the street railway demand and the use of saturated steam in the turbines, resulted in a comparatively high steam rate and the consumption of 6.95 to 8.37 lb. of coal per kilowatt-hour. The cost per unit, 0.77c., which includes operating charges and maintenance, is not excessive, although the coal costs only 82c. per ton delivered. With the load increasing as it should in the near future and the change from hand to mechanical firing, better results are expected.

The cost of 4.4c. per 1000 lb. of steam is unusually low, but only that steam coming from the engine was charged against the heating, the exhaust steam from the city water pumps and other sources being chargeable to other departments. On the other hand, a charge of $4.57 per ton of ice is excessive, but in the month of January only 36 tons were made, a daily output of but little over one ton per day of 24 hr. When running up to capacity in the hot summer months, the operating and maintenance cost ranges around 85c. per ton.

Due to the complexity of the service, it was a difficult matter to separate the costs. It would appear, however, that the engineer had the matter well in hand, for the records are complete and show familiarity with the details. The layout of a plant, its installation, the efficient operation of the equipment and finally, accurate records from which to obtain the cost of production, is a thorough test for any engineer. In the present case it is all the more creditable, as the engineer, while under his present employer in a smaller plant, fitted himself for the work by spending his evening hours in study. Mr. Best is to be congratulated on his success and the management in turn for giving him the chance to show his "mettle."

Applications and Types of Boosters--II

By John A. Randolph

SYNOPSIS—The use of the constant-current booster where both fluctuating and steady loads are supplied from the same busbars; also descriptions of the separately excited type and those used on three-wire systems.

In many installations, especially in private plants, it is necessary to supply a fluctuating or power load and a nonfluctuating or lighting load from the same busbars. To do this without disturbing the lights, a so-called constant-current booster and battery are connected into the power circuit, one form of which is shown in Fig. 1. There are a series and a shunt field winding on the booster, and all of the power load must pass through the series coil. The shunt coil is so wound that it tends to assist the busbar voltage while the series winding opposes the shunt. Ordinarily the shunt field predominates, causing the voltage on the power busbars to be slightly higher than that of the lighting busbars. When a heavy power load is thrown on the system, the additional current in the series coil at once lowers the booster pressure and consequently that of the power busbars, causing the motors to start more slowly. This action relieves the station generators of a sudden heavy demand for current and thus enables them to maintain their normal voltage on the lighting load. When the voltage of the power mains drops sufficiently, the battery floating on the line will at once begin to discharge and take part of the load, thereby preventing any disturbance in the operation of the system. As the motor

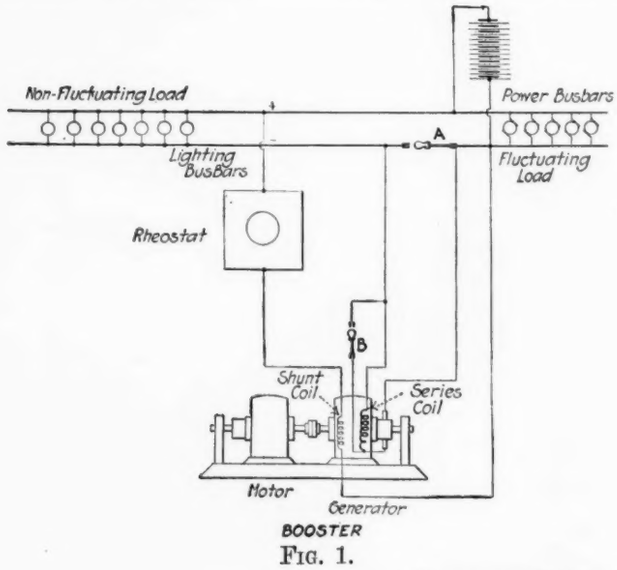


Fig. 1.

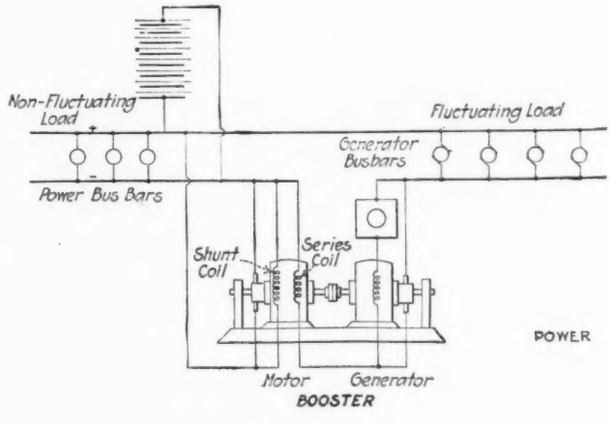


Fig. 2.

Types of Constant-Current Boosters

load again becomes normal, the current in the booster series winding becomes less and the booster voltage rises until the pressure on the power busbars again becomes normal. The battery will now stop discharging. A further falling off of the power load will cause the power busbar voltage to rise still higher, with the result that a charging current begins to flow into the battery. A system of this kind, when properly adjusted, will maintain practically constant current on the lighting busbars.

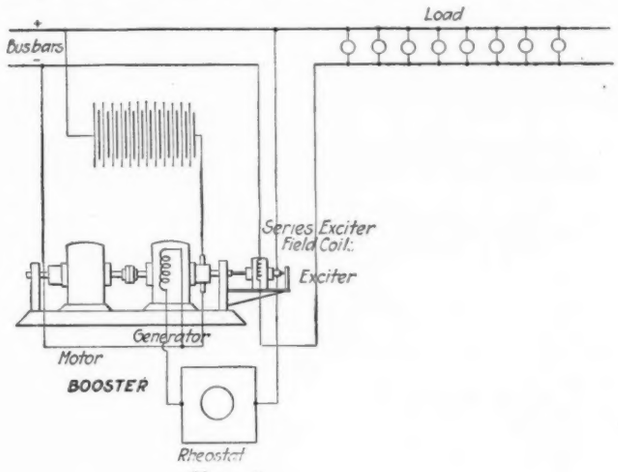


FIG. 3.

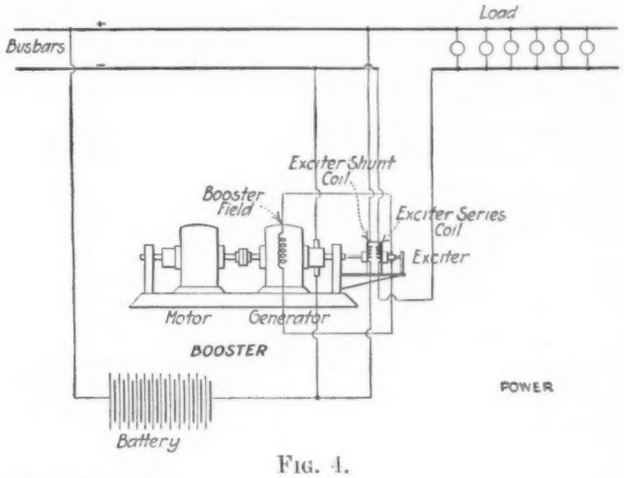


FIG. 4.

SEPARATELY EXCITED BOOSTERS

If it is desired to connect the battery to the lighting load, this can be accomplished by disconnecting the booster and closing the switch *A*. Switch *B* is for the purpose of cutting out the series coil in case it becomes necessary to apply a higher voltage to the power busbars than could be done with the coil in circuit, for battery charging or other reasons.

The connections for another type of constant-current booster are illustrated in Fig. 2. In this machine the voltage on the power busbars is raised and lowered to meet the fluctuations of the load, as in the case shown in Fig. 1, but it is accomplished in a different manner, the booster voltage being varied by changing the speed. The booster motor is compound wound and the power load must pass through the series coil, which is wound to assist the shunt winding. Therefore, as the load rises, the magnetizing flux of the motor will increase proportionately and result in decreased speed of the motor. This will cause the voltage of the booster generator to fall, thereby lowering the voltage on the power mains and enabling the battery to discharge. As the load falls off, the speed of the motor increases and brings the power voltage back to normal.

SEPARATELY EXCITED BOOSTER

In this type, the field excitation is controlled by a small exciter mounted either on the end of the booster shaft or on an independent base. A diagram of connections for one form is shown in Fig. 3. The booster generator has but one field coil, and this is in series with a regulating rheostat and the exciter armature, across the busbars. The exciter field coil is in series with the load and is so wound that the electromotive force which it induces in the exciter armature opposes that of the station busbars. The exciter voltage will vary with the magnetic flux produced by the field coil, or, in other words, with the current passing through the coil. When the external load becomes so great that the exciter voltage is higher than the busbar voltage, the current sent by the exciter through the booster field will be of such a direction as to cause the booster to assist the battery to discharge. On the other hand, when the external load becomes so light that the exciter voltage is less than that of the busbars, the direction of the current flowing through the booster field winding will be such as to cause the booster to assist the station busbars in sending a charging current through the battery.

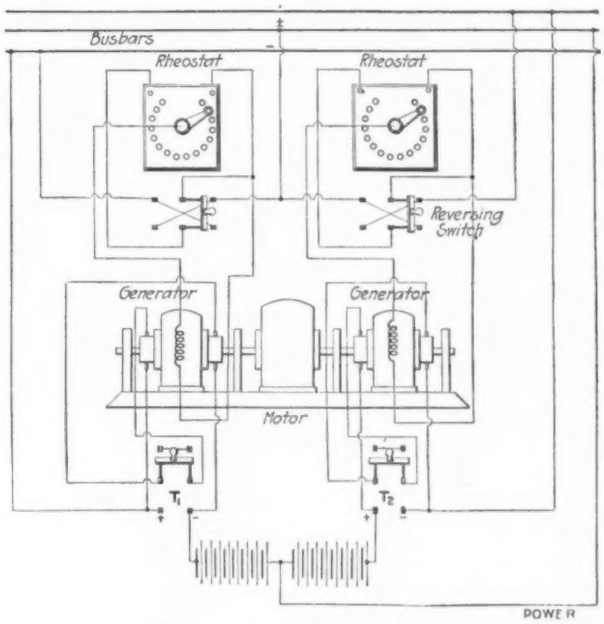


FIG. 5. BOOSTER FOR THREE-WIRE SYSTEM

Another type of separately excited booster is shown in Fig. 4. The exciter in this case carries two sets of field coils, one in series with the load and the other a shunt winding. The latter is wound to cause the exciter to induce a voltage in the booster which assists that of the busbars. The series winding opposes the shunt. The operation of a booster thus excited is similar to that of the differential machine, shown in Fig. 4, Part I (page 237, Aug. 18 issue). A heavy load through the exciter series coil tends to cause the latter to overpower the

shunt coil, with the result that the booster is made to assist the battery to discharge. As the load falls off, the exciter shunt winding again comes into action and sends a current through the booster field of a direction such as to cause the booster to assist the busbar pressure in sending a charging current through the battery.

Boosters for Three-Wire Systems

The types of boosters thus far considered have had but one generator. Sometimes, however, especially on three-wire systems, it is found more economical to use a booster composed of two generators driven by the same motor. Furthermore, where heavy currents are involved and a wide range of voltage is also desired, it has been found advisable to use on the booster-generators, armatures with two independent windings and two commutators. With this arrangement, the two windings of each armature can be operated either in parallel or in series, as may be desired. When in parallel the voltage will be half the value secured by series operation, but the current capacity will be doubled. Moreover, the use of double windings and two commutators renders it possible to carry heavy loads without unduly increasing the commutating parts of the machine. In Fig. 5 is shown the diagram of connections for such a machine as used on a three-wire system. There is but one field winding on each generator, and this is shunted between the neutral and one of the outside legs of the system. It will be observed that, in addition to a lead from an outside leg, the neutral is connected to each field rheostat. By this arrangement, the field coils, at the throwing over of the reversing switches, can discharge their back electromotive force of self-induction through a portion of the rheostate resistance, thus preventing a heavy arcing at the reversing switches.

Hand-Fired Furnaces for Water-Tube Boilers--I*

By Osborn Monnett†

SYNOPSIS—Typical designs of furnace, with dimensions, for burning bituminous coal smokelessly under horizontal water-tube boilers.

In applying the principles of the hand-fired furnace as outlined in previous articles to water-tube boilers, an effort has been made to approximate the same conditions and provide the same essential details that have been worked out for horizontal return-tubular boilers. Fig. 1 shows a typical setting for a hand-fired water-tube boiler which has proved satisfactory for bituminous coal. The boiler is a 116-hp. Geary and has one horizontal pass, but this type of setting can be easily adapted to any horizontal water-tube boiler. The essential feature of the furnace is, first, provision for heat absorption direct from the fire by the bottom row of tubes, thus producing the "cooling" effect so desirable with high-volatile coals. This is obtained by using T-tile for a distance of 4 ft. 10 in. from the front header. From this point the regular box tile covers the tubes and forms another element essential to the success of hand-fired furnaces, namely, a high-temperature zone into which the gases and air must pass. Back of the bridge-wall a deflection arch is provided of such height as to allow an area underneath of 50 per cent. of the grate surface. In settings of this type the

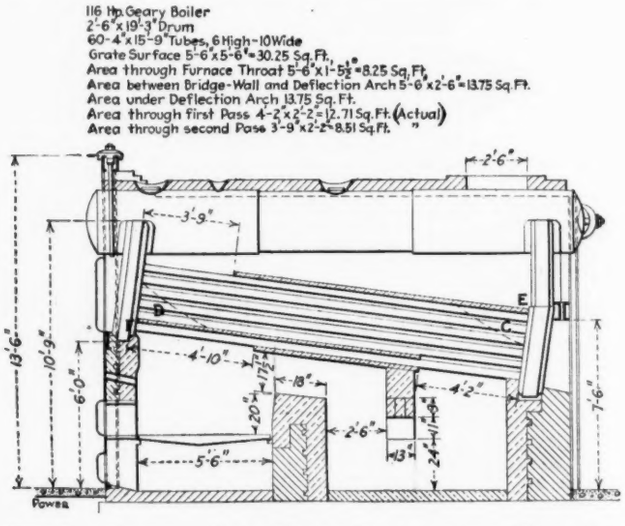


Fig. 1. Typical Hand-Fired Furnace for Horizontally Baffled Water-Tube Boilers

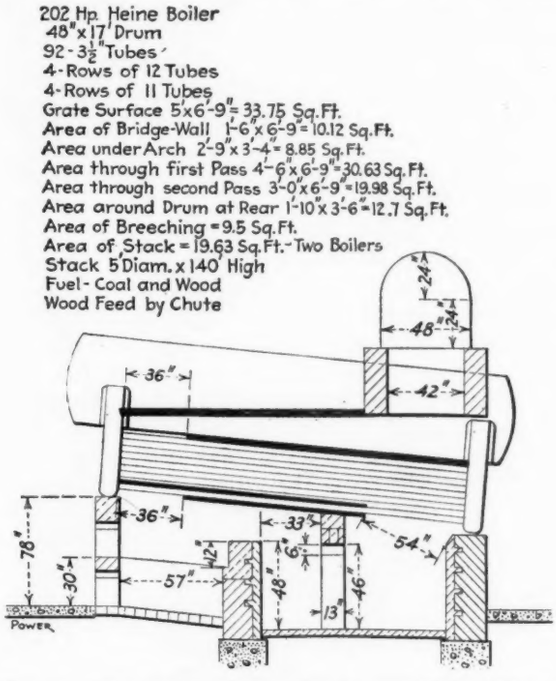


Fig. 2. Heine Boiler with Chute-Feed, Wood-Burning Furnace

*Copyrighted, 1914, by Osborn Monnett.

†Smoke Inspector, City of Chicago.

controlling height factor, which is usually measured from the floor line to the bottom of the front header, is governed by the ability to get the necessary area of 25 per cent. of the grate surface over the bridge-wall, 40 per cent. between the bridge-wall and deflection arch and 50 per cent. under the deflection arch.

With wide boilers containing three or four firing doors, the deflection arch is built in two or three spans with 13½-in. piers to decrease the strain on the side walls and obtain more permanent construction. If with these wide settings there is an area over the bridge-wall greater than the required 25 per cent. of the grate surface, 9-in. piers can be placed on the bridge-wall opposite the spans in the deflection arch to help break up the gases as they pass through the furnace.

In this type of furnace the air-admission panel doors and siphon steam jets should be used as with the horizontal return-tubular boiler setting. When using the Heine baffle shown, it sometimes happens that there are zones of inert gas, as indicated at *C* and *D*, Fig. 1. In this case the efficiency of the setting can be increased by opening up the baffle at *E* and *F* about 1 in. on every other tile. A bypass for the gases at either point makes the heating surface more effective. For all types of horizontal baffles this point is worth investigating, as in many instances the openings have improved results.

Fig. 2 shows another successful setting of this type. The fuel was a mixture of wood refuse and coal. It was necessary, therefore, to cool off the furnace as much as possible to prevent puffs of dense smoke while using the coal and at the same time have the furnace hot enough to handle the dry shavings fed through a chute. A compromise was effected with satisfactory results by removing 3 ft. of the box tile, which is a little more than half the length of the grates, and exposing the lower tubes for this distance from the header.

Fig. 3 shows how the same idea was applied to a Parker boiler, where the tubes are bared for a distance of 4 ft. from the front header by using T-tile. Box tile were used for the remainder of the distance, and a two-span deflection arch was provided.

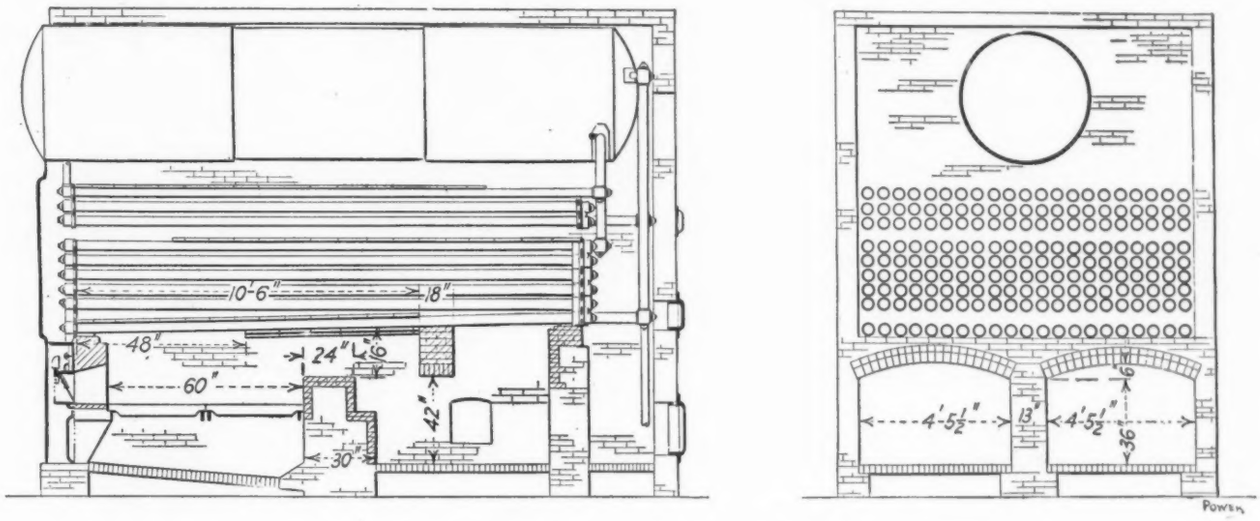


FIG. 3. PARKER BOILER WITH HAND-FIRED FURNACES

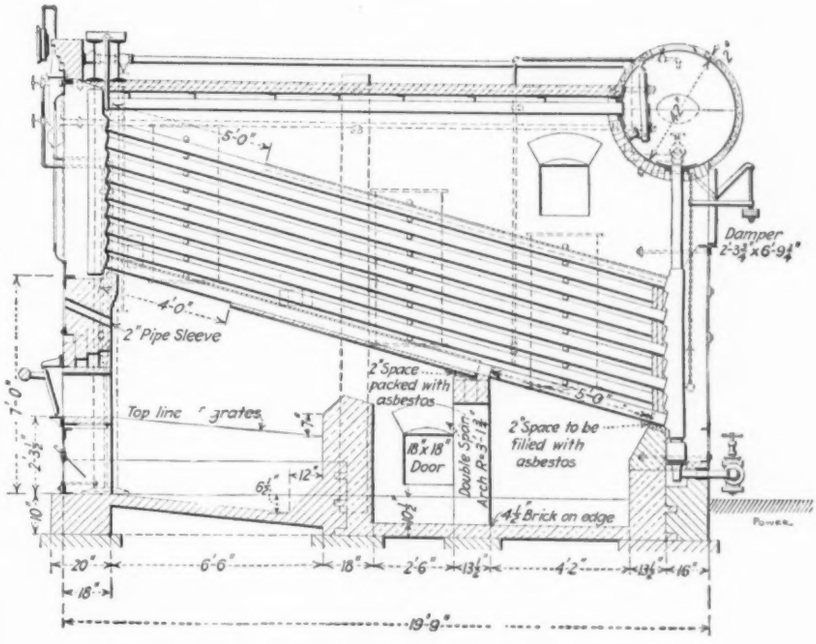


FIG. 4. HAND-FIRED FURNACES FOR B. & W. CROSS-DRUM BOILERS

Fig. 4 shows a typical hand-fired furnace applied to a B. & W. cross-drum boiler. This type of boiler has a tube pitch greater than any other of the standard horizontal water-tube boilers, so that a higher setting is necessary to give the proper area over the bridge-wall and sufficient space in the combustion chamber. The other characteristics of the setting are similar to those preceding.

Combination fire- and water-tube boilers are sometimes encountered, and where the tube length is approximately

18 ft., there is no trouble in applying the standard furnace. Such a boiler is shown in Fig. 5, which presents sectional views of a Kroeschell combination fire- and order of the department No. 8 furnace, described in a previous article, will work out nicely. Fig. 6 gives all the working dimensions necessary for installing a flush-

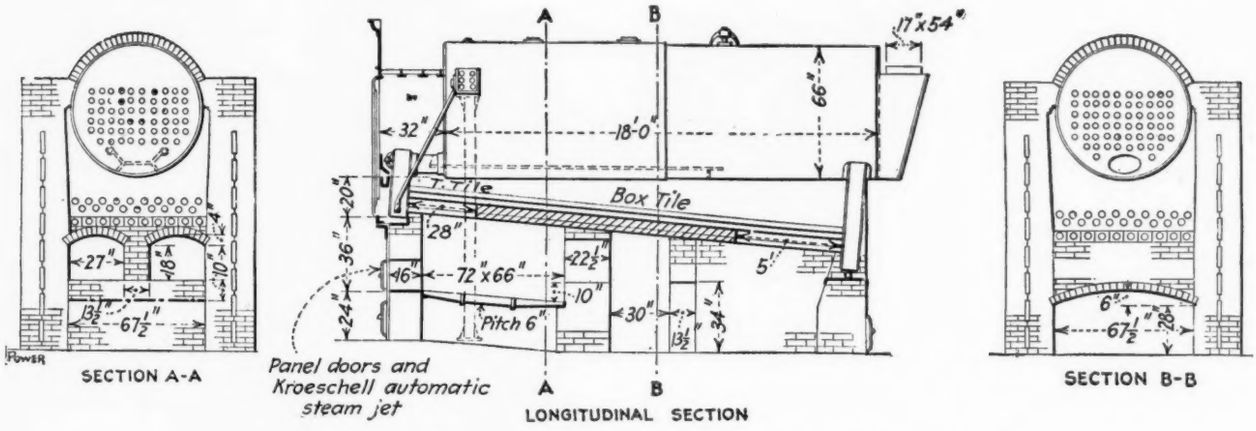


FIG. 5. KROESCHELL COMBINATION BOILER, HAND FIRED

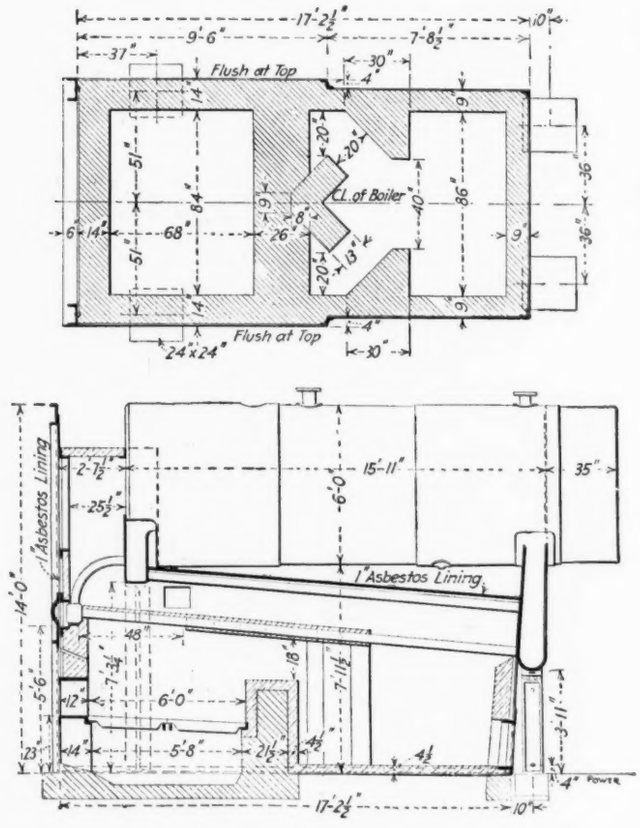
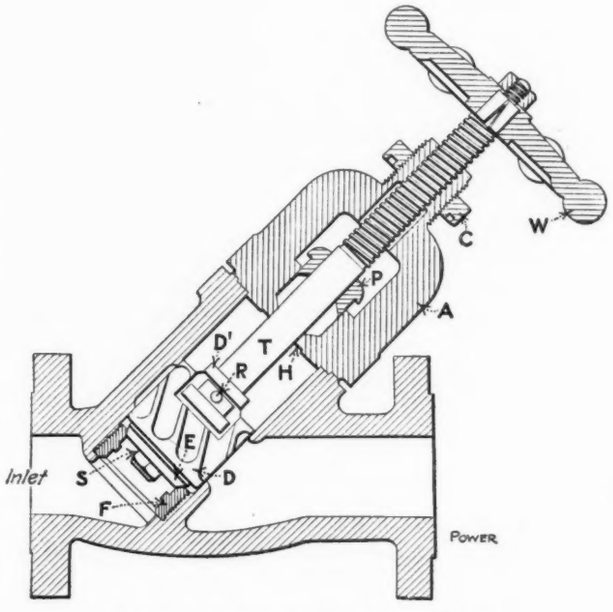


FIG. 6. HAWKES BOILER WITH DEPARTMENT NO. 8 SETTING

front, hand-fired setting for this boiler. The same furnace can be applied to regular horizontal water-tube boilers with 16-ft. tubes.

Powell Blowoff Valves

The illustration shows an improved Y-blowoff valve. The yoke top *A* is secured to the valve body by studs. The packing is held in place and tightened by the pusher gland *P*, which is moved by the outside screw nut *C*,



SECTION THROUGH BLOWOFF VALVE

water-tube boiler provided with T- and box tile in the usual manner, a pigeon-hole bridge-wall and a single-span deflection arch in the combustion chamber. There are occasions, however, where these combination boilers have short water tubes. Fig. 6 shows a Hawkes boiler with tubes approximately 15 ft. long. It is not possible to get a flush-front, hand-fired setting under such a boiler with a deflection arch and leave sufficient room at the back end of the tubes. In such a case a furnace built on the

above the bridge yoke, enabling the pressure to be adjusted with an ordinary monkey-wrench; the connections are not shown. As the faces *D'* and *H* fit tightly, the valve may be repacked under pressure.

The plunger *D* is of brass, milled to receive the collar on the stem *T*. Spiral grooves are cast on the outer face, which, receiving the pressure from the steam as the valve is opened, cause it to revolve as it nears the seat when

closing; this has the effect of keeping both disk and seat clean of scale and sediment.

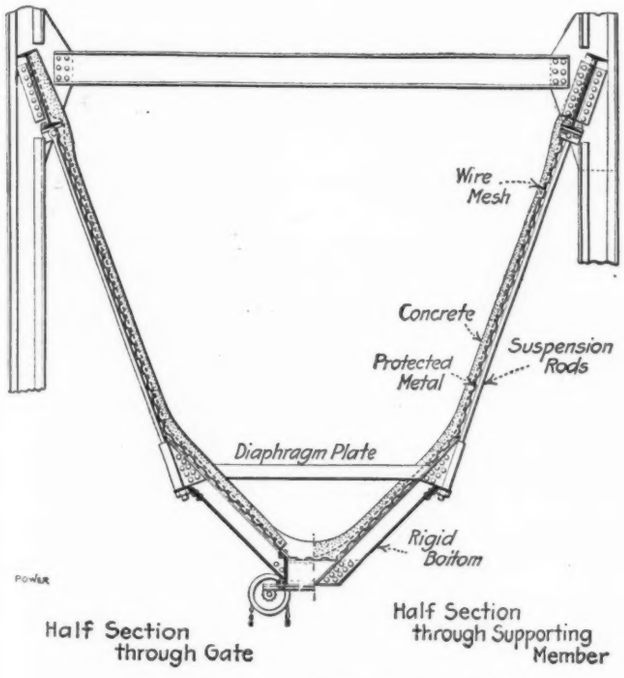
The seat ring *F* has been dropped lower to better protect it from the cutting effect of the rushing steam as the valve is opened. To the plunger is attached a regrindable, reversible and renewable disk, *E*, which is secured by the disk nuts, shown. The disk face and seat bearing are at such an angle that sediment or scale cannot lodge between them, either while blowing off or closing down the disk.

To regrind this valve a wire pin or nail is inserted through the hole *R* in the plunger. This locks the disk which is then rotated back and forth after putting a little fine brick dust or sand on the seat. The seat ring *F* has two faces; when one is worn it can be removed and reversed by means of the lugs cast in the throat of the ring. The disk *E* is not only regrinding and reversible, but is also renewable, and guaranteed to stand a temperature of 2000 deg. F. The valve is made in 2- and 2½-inch sizes with screwed or flanged ends and tested to 250 pounds hydraulic pressure.

This valve is manufactured by the Wm. Powell Co., Cincinnati, Ohio.

Baker Suspension Storage Bin

The design of the Baker coal-storage bin combines the principles of the suspension and hopper types of construction. The suspension rods and steel frames provide a flexible method of support as shown in the accompanying illustration.



Details of Coal-Storage Bin

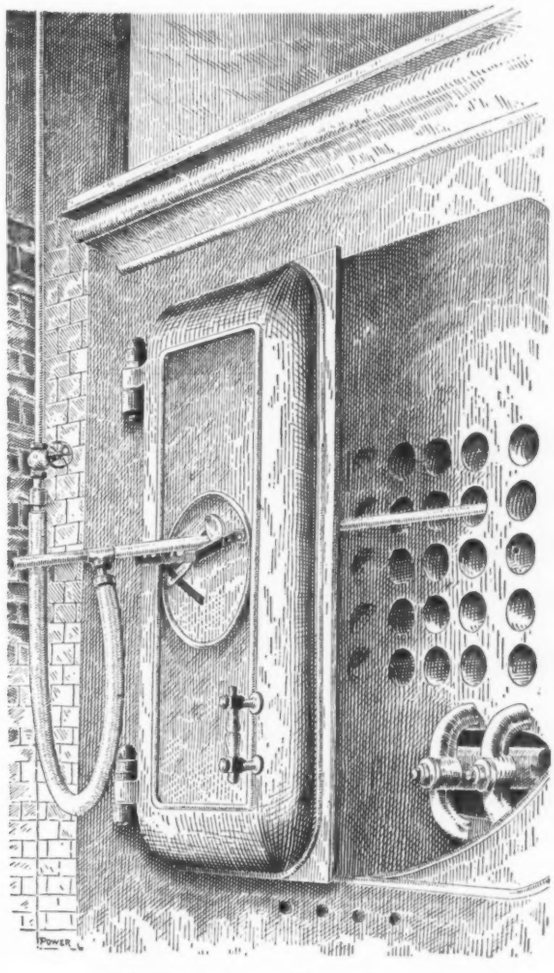
The bin lining is of concrete laid on asbestos steel, a sheet metal protected by a coating of asphaltum and covered with asbestos. The sheet metal is impregnable against moisture and acids, and no metal is directly exposed to the coal.

Breaking of the concrete lining, due to the slight bend in the supporting rods when the bin is loaded, is prevented by slats provided in the concrete, running at right angles to the suspension rods. The slats are filled with an asphaltum compound to prevent moisture from reaching the protected metal. The under side of the bin does not require plastering as the metal is protected by asphaltum-asbestos covering. The unit construction consisting of supension rods and bottom frame makes it possible to extend the bin structure when desired.

This bunker, which is built by Arthur G. McKee, Cleveland, Ohio, is also made with other forms of lining, such as unit slabs, varying in thickness from 2½ to 4 inches and wood.

Reiter Flue Blower

A flue blower, which will clean the tubes of a tubular boiler with the doors closed and without interfering with the draft or steam pressure, has been recently designed by the National Boiler Specialties Co., of Elgin, Ill. The



Reiter Boiler-Flue Blower

blower is nothing more than an ordinary pipe with a special nozzle, a handle at the outer end and a tee which is connected to the steam line by a flexible hose. The blower enters the front compartment through a hole in either door, which are ordinarily covered by the pendants. It is guided to the various tubes in a horizontal row by means of the notches in the straps hinged to the doors and the vertical movement to the various rows is gaged by the

notches in the supporting legs which pass through slots in castings attached to the doors. In each strap there is a notch for half the number of tubes in a row, and in each leg a notch for each row. The notches are so spaced with relation to the hole in the door that the blower will enter the various tubes without any trouble. For each case it is necessary, of course, to know the horsepower of the boiler, number of rows of tubes and the number of tubes in each row.

When the blower is turned on, the soot is blown back through the tube against the draft. The heavier particles settle into the combustion chamber and the finer particles are carried back by the draft through the other tubes toward the stack. In this way no soot escapes into the boiler room and the boiler can be maintained in full operation as usual. It will be understood that one tube is cleaned at a time, so that while cleaning, the draft is obstructed in the one tube only and is on all the other tubes.

The Compression of Ammonia Gas

By G. H. Crawford, Jr.

The relations existing between the back, head and mean effective pressures during the cycle of compression of ammonia gas in the cylinder of a refrigerating machine are often not thoroughly understood. While these relations follow theoretical laws much more closely than the similar relations in a steam engine, they have not been given much attention and are less well known.

It is common knowledge among those familiar with refrigerating engineering that, speed and head pressure remaining constant, a rise of back pressure increases the load on the prime mover. This increase is evidenced by a longer cut-off on the engine or a greater current consumption by the motor, depending on the nature of the prime mover. As the load of a refrigerating machine consists mainly of the compression of gas in the cylinder, it is readily understood that the increase of load is caused by the increase of the mean effective pressure.

might be written, the greater the back pressure, the greater the load. The second might be formulated, the greatest back pressure, the smallest load. The apparent contradiction is explainable. For any given head pressure, there is a certain critical back pressure at which the mean effective pressure in the cylinder is greatest. If the back pressure is higher or lower than this critical value, the mean effective pressure is less than the maximum. It happens that the compression of ammonia gas follows closely the theoretical laws. For adiabatic compression with no clearance, the mean effective pressure may be written:

$$m.e.p. = \frac{np}{n-1}\left\{\left(\frac{p_c}{p}\right)^{\frac{n-1}{n}} - 1\right\} \qquad (1)$$

where p is the back pressure, p_c the head pressure, and, for ammonia, $n = 1.3$.

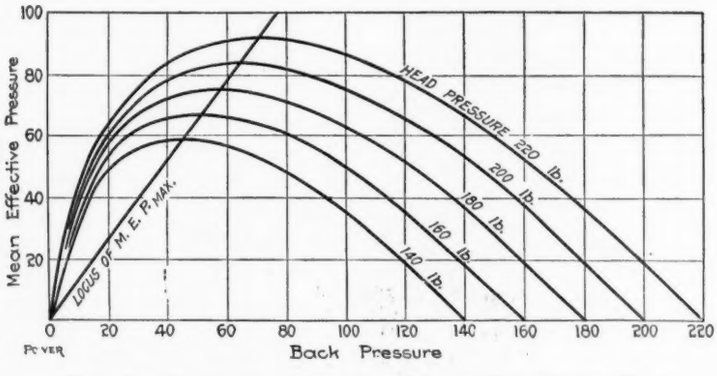


Fig. 1. Relations between Mean Effective, Back and Head Pressures

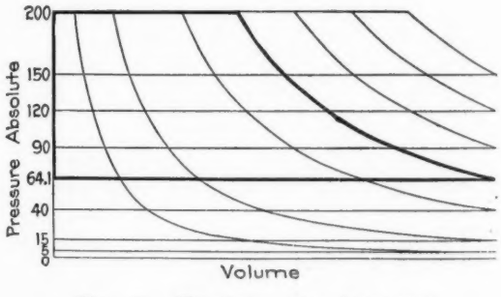


Fig. 2. Theoretical Ammonia Diagrams

On starting a refrigerating machine, especially if it is driven by an electric motor or an internal-combustion engine, whose characteristics make it necessary to have a low-starting torque, it is customary to bypass the two ends of the ammonia compressor, so that both sides of the piston are influenced by the same pressure—that of the condenser. By thus bypassing the gas, the machine is caused to start easily; in other words, a light load is placed on the prime mover. This light load proves that while pressure equalization exists, the mean effective pressure is low. When the pressures are thus equalized, the back pressure, acting on the piston, has been raised until it is equal to the head pressure.

When the two facts just mentioned are considered together, they are apparently contradictory. For the first

For any assumed head pressure, p_c, it is mathematically possible to find the back pressure p_x at which the mean effective pressure (m.e.p.) is a maximum. The problem works down to the simple relation

$$p_x = 0.3204\, p_c \qquad (2)$$

wherein p_x is the back pressure at which the m.e.p. is greatest for the assumed head pressure p_c.

By combining relations (1) and (2), a third relation is obtained:

$$m.e.p.\ max = 1.3\, p_x \qquad (3)$$

From (3) it is easy to solve for the actual value of the maximum m.e.p. As an example, let the assumed head pressure be 200 lb. per sq.in. $= p_c$. Then

$$p_x = 0.3204 \times 200 = 64.08\ lb.\ per\ sq.in.$$

and

$$m.e.p.\,max = 1.3 \times 64.08 = 83.40\ lb.\ per\ sq.in.$$

(Absolute pressures are used unless gage pressures are specified.)

These calculations show that with a head pressure of 200 lb. per sq.in., the maximum load occurs at a back pressure of 64.08 lb. per sq.in. At this back pressure, the m.e.p. is 83.4 lb. per sq.in.

These relations are shown graphically in Fig. 1, where the coördinates are m.e.p. and back pressure. The different curves are for different head pressures. It is seen that each curve has a maximum point, before and after which the value of the m.e.p. is lower. It is also seen that the maximum points of the different curves fall on a straight line, whose equation is

$$m.e.p.\,max = 1.3\,p_x$$

All these relations are of value to the refrigerating engineer. With them he can predict the maximum load to be carried for any condition of head pressure. Thus, with a head pressure of 220 lb. per sq.in., there is a possible maximum m.e.p. of over 90 lb. per sq.in., while if the head pressure is only 140 lb. per sq.in., the maximum m.e.p. is less than two-thirds as much, and a prime mover whose ultimate power is in proportion may be used. The working power requirements also may be estimated from the curves. Thus, if the back pressure is to be 30 lb. per sq.in., the difference in the power required to run the machine at 220 and 140 lb. per sq.in. head pressure is nearly 36 per cent. This demonstrates the actual value of keeping the head pressure as low as possible.

In Fig. 2 these relations are shown in a different manner. Seven no-clearance diagrams have been plotted, each with the same head pressure but with different back pressures from 5 to 150 lb. per sq.in. The heavily outlined diagram, back pressure 64.1 lb. per sq.in., has the greatest area, hence the greatest m.e.p. The areas for very low and very high back pressures are obviously less than the areas with medium back pressures.

A knowledge of these relations is also valuable to the operating engineer. He should realize that the higher the back pressure, the greater the refrigerating capacity of the machine. Similarly, the power required per unit of refrigeration produced decreases as the back pressure increases. From a consideration of both capacity and economy, it is desirable to operate at as high a back pressure as possible. The temperature in the refrigerator is the limiting factor, for this rises with an increase of the back pressure. By increasing the heat-absorbing surfaces in the refrigerator, it is often possible to maintain the desired temperatures at somewhat higher back pressures. The problem then reduces itself to the familiar one of balancing first cost and operating economy.

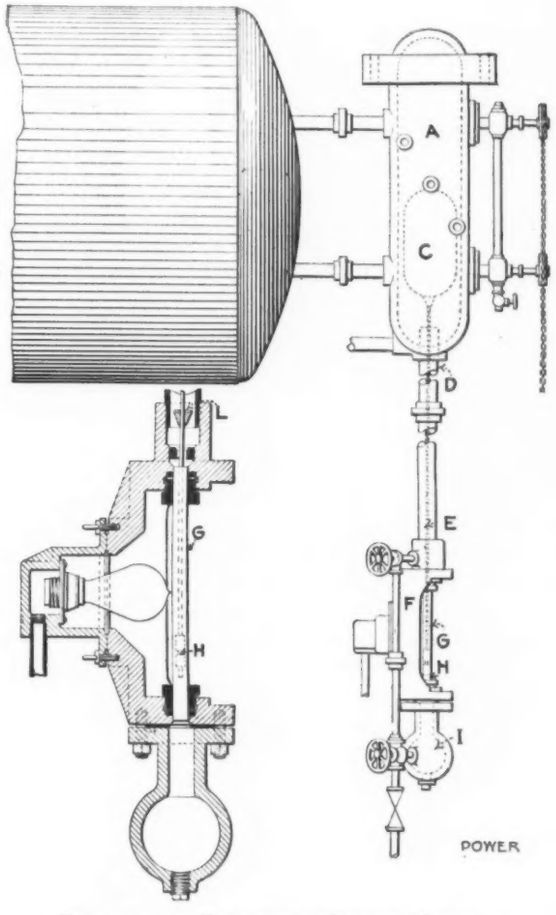
For a long time, the most common back pressure used in refrigerating and ice-making plants has been about 15 lb. per sq.in. gage. In some of the more recent installations, especially in those driven by high-priced internal-combustion engines, it has been found advisable to so increase the expansion or refrigerator side that the operating back pressure is 20 to 25 lb. per sq.in. gage. By so doing, smaller engines and compressors may be used and higher economies obtained than under the old arrangements. The added first cost of the expansion side is partly balanced by the decreased cost of smaller engines and compressors.

In pumping out any part of the refrigerating system in which there is considerable ammonia, as, for instance, a stand of condensers or liquid receiver, it might be advisable to allow nearly the full pressure to come on the suction side of the compressor, instead of throttling in the usual way. The m.e.p. would not be higher than for a much lower suction pressure, while the capacity for pumping out would be greatly increased and the time for the operation reduced.

It should be noted that in practice the values of the mean effective pressures are usually slightly less than shown in Fig. 1. This is due partly to clearance, of which all compressors have some, and partly to the fact that the compression of ammonia gas does not follow exactly the adiabatic curve of which $n = 1.3$. With leaky discharge valves, however, it is possible to obtain mean effective pressures higher than those shown.

Hydraulic Extended Water Column

In many boiler plants the water-glass is so high from the floor that it is difficult for the firemen to tell the water level accurately.



Details of Extended Water Column

The extended water column illustrated is designed to bring a water-gage level with the firemen's eyes. The device consists of a water column *A*, piped to the boiler in the usual way. Inside is a float *C*, connected to an

indicator rod *E*, in the extension pipe *D*, to which is screwed an extension gage casing *F*.

On the lower end of the extension rod *E* an indicator *H* travels up and down in the extended gage-glass at *G*. An inclosed electric light illuminates the indicator *H*.

If the lower glass breaks the apparatus cuts itself out by the check valve *L* seating, when the glass can be replaced; the upper gage-glass is, however, available. This device is made by the Edwards Steam Specialty Co., 343 South Dearborn St., Chicago, Ill.

Massachusetts Boiler Law and Rules--I

By C. J. Andrews

SYNOPSIS—Critical analysis of the Massachusetts Boiler Law and the Rules laid down by the Board of Boiler Rules. This will appear in three installments. This first one discusses the law and the rules up to Part III. The rest will be treated in subsequent issues.

Since the Massachusetts Boiler Law and Rules have been used as a pattern by several other states and largely copied in the uniform boiler law proposed by the American Society of Mechanical Engineers, to be generally adopted to govern the construction and operation of steam boilers, a discussion of the good points as well as the defects that have appeared in their practical application may be of interest. Some parts of the law and some of the rules have proved to be good, while others work hardships, or at least seem unnecessary and inadvisable.

The general scheme of the Massachusetts law providing a board to formulate the rules and change them whenever advisable, is good. This should be adopted in any boiler laws enacted, for flexibility in the rules is a necessity. Rules cannot be made that will not require changing from time to time. Many changes have been made in the Massachusetts rules since they were first drawn, but if the board has erred in exercising this authority, it has been in not making enough.

Massachusetts Law

Section 1 of the law specifies the kinds of boilers that are exempt from inspection and provides that other boilers in the state are to be inspected once annually. It also provides for uninstalled boilers that were in the state at the time of the passage of the act, but which did not conform to the rules. The provisions of this section seem to be proper and well chosen.

Sections 2 to 5 inclusive deal with inspectors and how inspections are to be made and the reporting of boilers to the inspection department of the state by the owners. Nothing in these sections is superfluous and they may well be followed.

Section 6 indicates how inspectors in the employ of insurance companies may become qualified to inspect boilers for use in the state. While its wording shows no defects at a glance, several have become apparent by the enforcement of the law. In the first place, three members of the state inspection department are designated to act as a board of examiners of inspectors of equal rank, for the insurance companies. This is not customary in making any similar appointments under municipal, state or national government control. The qualifications of candidates for inspectorship should be determined directly by the board of boiler rules, or at least the examinations should be under the board's supervision. This is done in Ohio; examinations are held at regular intervals by the board of boiler rules.

Another faulty feature is that the examination of the applicant is entirely oral. An examination without definite indication of the right and wrong answers is not satisfactory to an applicant who is refused a certificate, and its fairness can never be above suspicion. Ohio holds written examinations and the papers are marked and turned in, so that the applicant may know his standing.

A third defect of this section is that the certificate is revocable, not only for cause, but also if the holder should leave the company by whom he was employed when he secured it, and a re-examination is necessary to secure a new one. Why this should be is difficult to see; an inspector's qualifications are not affected by merely transferring his services from one company to another. Here again the Ohio law, although generally patterned after that of Massachusetts, is superior. It does not require that an applicant be employed or even intending to enter the employ of an insurance company or the state department, before he may take an examination, and his examination is only to determine whether he is competent to make boiler inspections. If so found, he is granted a certificate, which does not give him the right to inspect boilers, but only to apply to any insurance company or to the state inspection department for a position. They can engage him without delay, knowing that he will be granted a commission upon request. If an inspector changes from one company to another, it is only necessary for his new employer to request a new commission for him.

Under the Massachusetts law, the applicant must first secure a position as inspector, or the promise of one, and then appear before a board for an oral examination. If he fails, he probably has no idea why he was considered incompetent. He may appeal and be re-examined orally by five examiners chosen from the same inspection force, whose findings are final. The law provides that no one of the first three examiners may act on the board of appeal; but does this safeguard the interest of the applicant sufficiently?

Section 7 provides, in granting an appeal from the decision of the first examiners, that the applicant may have a representative of the company by whom he is or is to be employed present during the examination. Under the Ohio law, one whose certificate has been revoked may have counsel at the hearing of an appeal, and is able to learn whether he has had fair treatment.

According to Section 6, ninety days must elapse after an examination before an applicant may take a new examination, except in the case of appeal. This in itself would be all right if an inspector could change from one company to another without losing his certificate, but it may be a hardship. In one case, an inspector lost a position with one company, through no fault of his own, and because he had been recently examined, and although passed, he could not be re-examined until the expiration of the prescribed 90 days. He was worse off than if he had been found incompetent, for then he could have appealed and taken a new examination at once.

All the provisions in *Sections 8 to 15* inclusive are apparently needed and seem properly drawn to accomplish the desired end.

Sections 16 to 19, inclusive, seem necessary and in order and should be copied by other states.

Section 20 deals with fusible plugs; no very serious objection may be made to this section except that lead is specifically mentioned as one of the metals to be used for filling such plugs, whereas tin is considered better. It would seem best to have left the specification of fusible plugs to the board of boiler rules.

Section 24 is the next deserving comment. It provides for the appointment of the board of boiler rules and wisely selects them from the boiler-inspection department, the boiler-using interest, the boiler-manufacturing interest and the boiler-insurance interest, with one member an operating engineer. Selecting members to represent these various interests is an advisable plan for a state or municipal government to follow. It would also seem wise to specify that the members must be well versed in the operation and construction of steam boilers. The object of the board being to modify old and make new rules to govern the construction and operation of steam boilers, its members should be thoroughly conversant with the subject.

Section 26 prescribes the duties of the board of boiler rules and wisely provides that public hearings be held twice a year to consider petitions for changes in the rules. A good requirement in this same section is that any changes in the rules, even if proposed by the board, must be advertised, so that the public may have knowledge of those contemplated before they are actually made. Provision that changes shall take effect six months after they are approved by the governor of the state prevents working a hardship on the manufacturers or purchasers of boilers who may have contracts in process of completion. Where a manufacturer wishes to make a special type of boiler, he must submit drawings to the board for its approval. Probably it would be well if this rule applied to all boilers to be constructed for use in the state. The plans submitted could be given a designating number, and as many boilers as were desired could be made from these plans with the certainty that they would meet the requirements of the law, as long as the material used and the methods of construction complied with the law. The province of Alberta, Canada, has a rule to this effect which is found to be convenient and tends toward the standardization of boiler design.

The rest of the law, including Section 30, seems to be just and proper and to need no criticism.

Boiler Rules

The division of the rules into three parts is admirable and should be adopted by others. Nothing hinders the enforcement of any law so much as to have it conflict with the property rights of the citizen. Recognizing this, different rules were prescribed for boilers installed and in use before the law went into effect. These constitute part one. The rules in the second part apply to boilers already in the state as well as to new boilers that are to be entered after the passage of the law. The third part is composed entirely of rules that apply to boilers to be installed after the passage of the law and contains by far the most rules.

Part I of the Rules

This part is very short, consisting of a single section.

Paragraph 2 specifies that 55,000 lb. tensile strength for steel and 45,000 lb. tensile strength for iron shall be assumed when the actual values are not known. This is a wise rule, for it is conservative and gives the inspector definite authority as to what he may do under certain conditions. Unless a rule of this kind is inserted, there is continual wrangling between the inspectors and the boiler owners as to the correct value to be used in each case.

Paragraph 3 specifies that the factor of safety for butt joint boilers shall be 4.5, which is 0.5 less than the factor of safety required for new boilers of similar construction. While it is illogical from purely a mechanical standpoint to permit a higher pressure on an old boiler than on one just built, the interference with the property rights of the citizen is of more importance than the slight difference in the safety factor. Boiler construction in Massachusetts was in advance of that in most other states when this law was passed, and the pressures allowed on the boilers in that state were on a higher factor of safety than in many other states, hence prescribing a factor of 4.5 for butt-strapped boilers was not a hardship on the owners. When Ohio passed a boiler law, the safety factor on boilers already in use was fixed at 4 as a minimum, and the inspector was permitted to raise the limit where he thought it necessary to secure safety.

Paragraph 4 prescribes a method to be used to determine the size of rivet holes, when their size cannot be directly determined by measurement, by specifying the various sizes that are to be assumed for the different plate thicknesses. This rule is very commendable and is in keeping with the rule specifying the tensile strength to be assumed for unknown plate.

Paragraph 5 undertakes to specify the arrangement of safety valves for boilers under various conditions, and seems to be unnecessarily cumbersome to attain the desired end, i.e., safety. A rule requiring all to have a given area of safety valve for a given area of grate and a fixed pressure, and prohibiting two boilers operated at pressures differing more than 100 per cent., being connected to the same pipe system, would have been much simpler and probably provided greater safety. The present rule relies on the safety valve of an equivalent area to the connecting pipe, to prevent an excess pressure coming on the low-pressure boiler or boilers, while it is well known that the relieving capacity of a safety valve is not nearly so great as its nominal size would indicate. This fact is made evident in the formula given in the same rules for estimating the size of safety valves to perform a given duty.

Part II, Section I

Part II, as has already been stated, applies both to the boilers installed at the time that the law went into effect and to the new boilers to be installed in the future.

Paragraph 1 correctly limits the pressure on boilers constructed wholly of cast iron to 25 lb., and there is also a proper provision in *Paragraph 2,* limiting the pressure on boilers using cast-iron headers to 160 lb.

Paragraph 4 specifies that the resistance of boiler plate to crushing is to be taken at 95,000 lb. per sq.in. This rule might have been omitted, for the value of the crushing strength of steel plate is very uncertain and only comes into play with practical boiler seams on double-riveted joints where the outside straps are narrower than the inner straps. The omission of this factor in the calculation of the strength of boiler joints would have simplified the subject considerably and detracted nothing from the safety of the rules. The shearing strength as given in *Paragraph 5* follows the customary values used for this purpose by nearly all the modern authorities.

Paragraph 7 gives the factor of safety to be used on boilers, the shells of which are constructed with lap longitudinal seams, these factors running from five to six on externally fired boilers, dependent on their age, and five for boilers, the shells of which do not come in contact with the products of combustion. While this grading of the safety factor was all right for Massachusetts, it would hardly do for any other state. The customary minimum factor for boilers throughout the United States may be said to be 4; and while it would be better 5, such a change applied to boilers already in use would invade the property rights of many owners. The factors adopted by Ohio seem more logical.

Section 2

The criticism of Paragraph 5 of Part I applies the same to *Paragraph 2* of Section 2 of Part II. Limiting the difference in pressures to be permitted on boilers connected to the same steam-pipe system would better guard against over pressure on the low-pressure boilers of such a system.

Paragraphs 3, 4, 5 and 6, relating to safety valve areas, are standard and require no changes.

Paragraph 7 could be improved by specifying that in new installations the safety valves should be placed not to exceed a given distance from the boiler and on a separate and independent connection; there should be more specific and complete directions as to the proper support and anchorage for escape pipes when used on safety valves.

Paragraph 9 could be improved. Limiting the safety valve size to 5 in. is good, but requiring the seats of all safety valves to be beveled or inclined to the center line of the spindle about 45 deg. is not; some of the best safety valves made have flat seats. A requirement that the boiler owner must see that the lifting device specified for such valves is in place at all times, and that the engineer in charge of the boilers should see that each safety valve is tested once a day, would increase safety of boiler operation. The locations of fusible plugs, as specified in *Paragraph 11,* are good except for vertical tubular boilers. There a fusible plug is practically useless and often causes serious trouble.

Paragraph 15 might be improved by specifying that the ¼-in. connection for the inspector's test gage have a siphon which can be filled with water to avoid injury to the gage, from steam coming in contact with the spring. There was probably no logical reason for specifying two gage cocks for boilers operated at pressures below 25 lb. and three for boilers operating at higher pressures, as specified in *Paragraphs 17 and 18,* except to avoid too great an interference with boilers already installed; if this was the purpose the rule is fully justified.

Paragraph 19 is a good rule except that the feed water must be discharged below the lowest safe water line. This rule bars the steam space feed, which is widely used in some sections of the country, and is one of the best methods. The last sentence of this paragraph states that means must be provided for feeding a boiler with water against the maximum pressure allowed on it. The cause of safety would have been aided if some other means of feeding a boiler had been required besides the pressure from a water-works system, except for heating boilers operating at pressures below 25 lb.

If the water-column connection to the steam space of a boiler can be considered a steam outlet from the boiler, *Paragraph 20* should have been modified to exclude a valve on such connections, for evidently the rules intend to discourage using valves there, and they should.

Paragraph 22, if strictly adhered to, would have the damper regulator connected directly to the steam space of the boiler, while later in the rules the top water-column connection is specified as a suitable place for attaching it.

Paragraph 23 specifies that where furnace mouth-piece protectors are used and valves are placed on the pipes connecting them to the boiler, such valves shall be locked open. The safety of such an arrangement would be increased if safety valves were required for such attachments when valves were used on the connecting pipes, these safety valves to be set 20 lb. in advance of those on the boilers.

Sections 4 and 5

are proper and serve admirably the purpose for which they were intended.

Section 6

Paragraph 1 of this section would be improved if, when a power boiler is to be tested by hydrostatic pressure and is connected to a steam main in service at the time, it required two stop valves between the boiler and the steam main, or, if only one valve is used, breaking the connection with a blank flange before the test. Serious accidents have occurred in this way, since the strain on the valves, due to expansion and contraction of the parts on account of the unequal temperatures on each side of the valves, is very severe.

Section 7

The only comment to be made on Section 7 is that it would have been better if the method used for calculating the efficiency of boiler joints had been placed in an appendix, since the matter contained is in reality not a rule laid down by the board of boiler rules, but simple instructions on how the efficiency of boiler seams is estimated.

In *Paragraph 6* of this section, which explains the calculations for a quadruple-riveted joint, those given under "D" for the strength of the joint, considering the breaking of the net section of the plate through the second row of rivets, could have been omitted to advantage since this kind of a failure is never concerned with the efficiency of a boiler joint where rivets of uniform size are used.

Section 8

This section deals with the kind of certificate to be issued and how it is to be posted by the owner of the boilers inspected. Its prescribed wording is such that a separate one must be issued for each boiler, unless all boilers are exactly the same and have been inspected on the same day. This duplication of certificates in the average plant is not important, but in large boiler houses a scheme for designating the boilers by numbers and dating the certificates by months only, would go a long way toward simplifying the subject, without detracting from the efficiency of the service.

Cracked Headers on a Water-Tube Boiler

At Detroit, Mich., a slight leak was discovered at the front header of a Geary water-tube boiler while under steam. The boiler had been operated at 185 lb. for 12 years.

The front cap and rear tube plates had cracked at

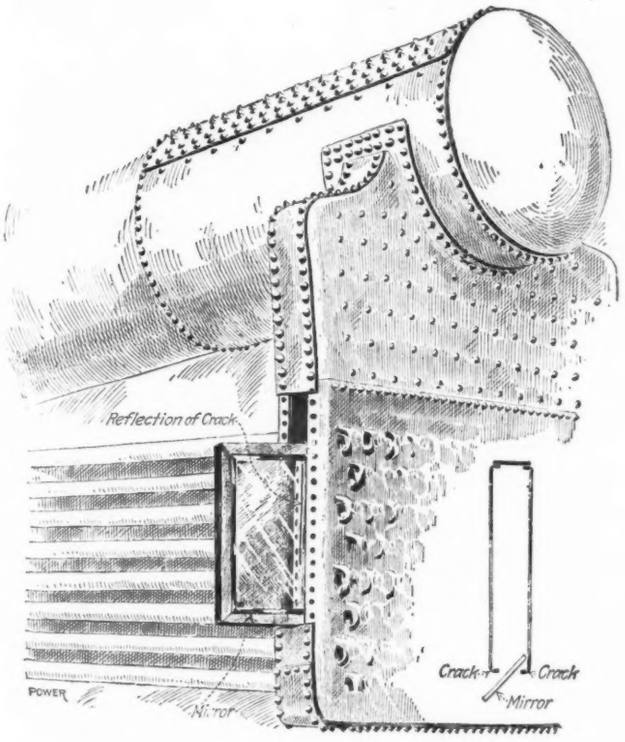


Fig. 1. Sketch Showing Location of Crack, by Means of Mirror, on the Inside of the Front Hand-Hole Plate Flange

each of the curves of the flange for a distance of nearly 2 ft., as shown in Fig. 1, which was made from a photograph of the reflection on a mirror inserted between the tube and hand-plate sheets, showing the crack on the inside of the front plate at the bend. The tube sheet was cracked at both sides in a similar manner, as shown by the plan drawing at the right.

The boiler had a steel drum 18 ft. 8 in. long by 24-in. in diameter, made of ¼-in. plate with an 87 per cent. joint. The tube and outer sheets were of $\frac{7}{16}$-in. plate, with 1¼-in. stay-bolts pitched 4½x5 in. The wrapper plate connecting the tube and the other plate was only

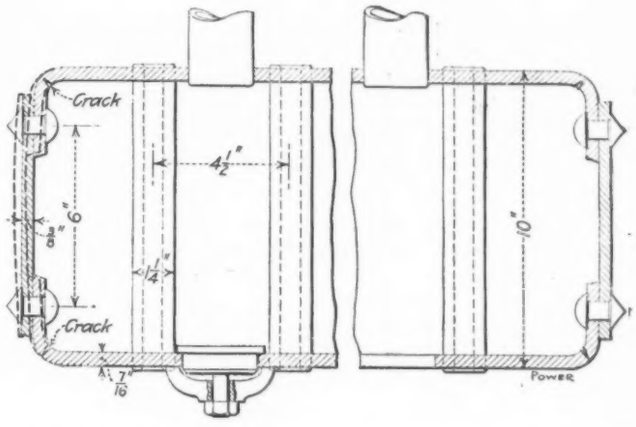


Fig. 2. Showing Cracks in Curves of Plates and the Curvature Assumed by Wrapper Plate

⅜ in. thick and was 6 in. wide from the rivet holes, center to center, the distance between the tube and outer sheets being 10 in.

The failure, which fortunately did no damage, was due to the inherent weakness of the ⅜-in. wrapper plate (see Fig. 2). The front and tube sheets are held together by stay-bolts, and the wrapper plate makes a tight joint between the two plates. Suppose a piece of thin sheet iron were riveted in place instead of the ⅜-in. wrapper plate, and steam pressure were applied from the inside, but not enough to tear the sheet iron away; the thin sheet would bulge outward. If a thicker piece were used, strong enough to resist the 185 lb. pressure carried on the boiler without rupturing, but not strong enough to remain in its original position, it would tend to assume the same curved and bulged position as the thin sheet. Owing to its difference in strength, however, it would cause the flanges on the front and tube sheet to bend at the curve of the sheets, as shown by the dotted lines, Fig. 2. This bending would eventually result in a crack, as shown in Figs. 1 and 2. A wrapper of proper thickness would prevent the bending of the plates at this point with the changes in boiler pressure.

This boiler, aside from the weak wrapper plate, was reasonably safe for 185 lb. pressure, but should not have been allowed to carry over 100 lb., because of this weak point in its design. A micrometer measurement of the deflection of the plate measured 0.023 in. at 185 lb. working pressure and 0.39 in. under a hydrostatic pressure of 50 per cent. over the working pressure.

This case exemplifies the danger of hidden defects. It was impossible to have access to these plates without tearing down the brickwork, and their thickness could be determined only by drilling or removing a rivet. The advantage of boiler inspection during construction is emphasized by the failure.

Drying Out Oil-Immersed Transformers

By H. M. McLellan

SYNOPSIS—The usual methods for drying out transformers and transformer oil, with practical suggestions to guide the operator in carrying out the work.

Oil-immersed transformers should be dried out before they are connected to the circuit, in order that every trace of absorbed moisture may be removed. The transformer and the oil should preferably be dried separately, the transformer at a temperature of 80 to 90 deg. C. (176 to 194 deg. F.), and the oil at a temperature of from 100 to 110 deg. C. (212 to 230 deg. F.).

The simplest way to dry the transformer is to short-circuit one of the windings, generally the low-tension one, and connect the other to an alternating-current supply, with a voltage of from 1 to 5 per cent. of that for which this winding is arranged. The voltage must be such as to set up a suitable drying current in both windings of the transformer. This current varies with the size of the transformer, and is approximately as follows:

	Normal Current
Transformers up to 5 kv.a	1½
Transformers 5 to 20 kv.a	1¼
Transformers 50 to 200 kv.a	1
Transformers 50 to 200 kv.a	0.6
Transformers 200 to 500 kv.a	0.4
Transformers above 500 kv.a	0.2

These figures are intended to serve only as a guide as the current necessary to obtain the desired results varies considerably with the type of transformer. In every case, the following points should be carefully attended to and the current adjusted accordingly:

Place two or more thermometers in such a way between the windings that the bulbs directly touch the insulation of the copper. It is not sufficient if they touch only the insulation washers, etc., as the temperature of these parts, as a rule, is considerably lower than that of the insulation immediately around the conductor. These thermometers should be securely held in place by waste, but care must be taken that nothing intervenes between the bulbs and the insulation.

The current should be adjusted to give a steady temperature of 90 deg. C. If it is not possible to adjust the current accurately and if the temperature rises above 90 deg. C., the current must be switched off until it falls to about 80 deg. C., otherwise the insulation may be damaged. The current should then be switched on again, then off, and so on throughout the whole period of drying. Be careful not to break the thermometers, as drops of mercury might stay between the windings and cause trouble.

It is preferable to dry the transformer outside the tank, as it is then easier to get rid of the moisture and control the temperature. This is important, as any indications of excessive temperature which may occur are much more apparent when the transformer is outside than when it is inside the tank. For instance, if the thermometers are not placed correctly, the real temperature of the transformer will be considerably in excess of that shown; and parts of the windings may reach an excessive temperature as indicated by smoke and the discoloration of the insulation. If there are any evidences of such excessive temperatures, the current must be switched off immediately, and the drying afterwards continued with less current. In no case must the transformer be left without attention during the drying process.

The drying out in air should be continued from 6 to 12 hr., at least, after a temperature of 80 to 90 deg. C. has been reached. In the case of large transformers (above 500 kv.a.) for high voltages (above 10,000 volts), the drying should be continued for 24 hours. The time necessary depends upon the size of the transformer and the temperature obtained.

In case the available voltage is too high to be connected directly to the transformer, as described, a resistance may be put in series with either the high-tension or low-tension windings, depending upon the resistances available, as both the current and the voltage to be taken up by the resistance varies according to the ratio of the transformer.

Another alternative is to connect the high-tension or the low-tension windings of several similar transformers in series, so as to give each only a portion of the supply voltage. Only the windings to which the voltage is applied need be connected in series, the other windings being short-circuited on themselves. This series connection is not feasible with three-phase transformers, however, unless the windings can be separated.

Still another method of drying, if low-voltage current is unavailable, is to place the transformer in its tank and pass heated air over the coils. In this case a good circulation should be maintained.

The oil may be dried independently of the transformer, either by external heat, by blowing heated air through it, by means of electrical resistances inside the tank or by passing it over unslacked lime. If the first method is used, caution is necessary in order to prevent ignition. The oil should be kept at about 110 deg. C. (230 deg. F.) for about 12 hr., or longer if the temperature is lower than above.

If there are no means of drying the oil separately, it may be dried with the transformer. In this event the transformer, after having been first dried separately, is placed in its tank of cold oil and the current switched on again. When the transformer is in the oil, however, the current should be about 50 per cent. above full-load current. The temperature must be watched by means of a thermometer in the upper layer of oil, and this part of the oil should be heated up to 110 deg. C. (230 deg. F.). When this temperature is reached, the current should be switched off until the temperature drops to 90 deg. C., then switched on again, this operation being repeated until the oil has been kept heated for 12 hr. or more.

When the oil is heated by means of the transformer itself or by resistances placed in the oil, it should, if possible, be stirred at frequent intervals in order to bring the cool oil at the bottom to the top, where it can be heated more quickly. In order to shorten the time for

drying, the tank should in all cases be lagged to prevent radiation; this also greatly reduces the amount of current necessary. The tank cover must be removed during the drying process in order to allow the vapor to pass off.

There is still another method in which the transformer and the oil may be dried together. This is by means of internal heat through the transformer coils in conjunction with a vacuum in the tank. Owing to the necessity of a vacuum pump and the difficulty of keeping the tank vacuum-tight, this method is not so well adapted to ordinary conditions.

With small transformers for comparatively low pressures, the oil should be dried for about 12 hr., as described. With transformers up to 500 kv.a. and 10,000 volts, the drying should occupy up to 24 hr. In the case of still larger transformers and higher pressures, it is sometimes advantageous to extend the drying over three or four days, it being advisable to allow the transformer to cool down to room temperature once or twice during the process.

When the low-tension winding is short-circuited, and a current at comparatively low voltage is passed through the high-tension winding, there will be no danger of excessive pressures in the windings. If however, current is brought in on the low-tension side, a dangerous pressure may be induced in the high-tension side, especially if the short-circuit should be broken by accident. Special care must, therefore, always be taken to insure that the short-circuit is never broken before the transformer under test has been disconnected from the supply circuit.

Patching Boilers

By S. Regral

SYNOPSIS—Practical points for measuring boiler patches, a method of riveting them and why different-shaped patches are used.

The problem of laying out a boiler patch is simple, and but few points need be borne in mind. The defective portion of the plate must first be removed, but no more than is necessary, so as to keep the patch as small as possible. A circular-shaped patch is the best when practical, as it weakens the shell less than one having a straight seam and is less likely to give trouble from leakage, which often occurs at the corners of a rectangular patch.

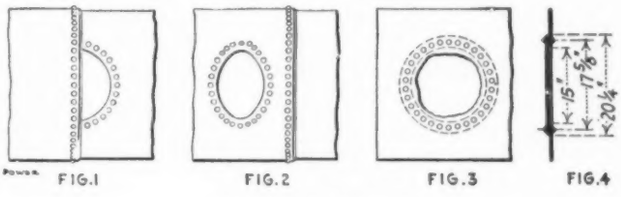
In all cases, the straight portion of the longitudinal seam should be as short as it can be made, and that portion of a single-riveted patch should never exceed 24 in. in a boiler carrying a pressure of 100 lb. or over. If a triple-riveted, butt-strapped boiler is designed to carry 125 lb., and a single-riveted patch of large size is put on, it becomes at that particular point a single-riveted, lap-joint boiler. Of course, the surrounding portion of the boiler, being stronger, tends to reinforce the weakened part, but the extent of this weakening depends on the length of the straight portion of the side seam.

It is usually considered impractical to double rivet a patch, because patches are nearly always in the part of a boiler exposed to the most intense heat, and it is generally believed that a double-riveted patch cannot be kept tight under these circumstances. The stress on the longitudinal seam is the greatest and that on the circumferential seam is the least, consequently the more nearly the seam of a patch approaches the circumferential seam, the less is the strain on it.

A practical illustration is the case of the ordinary horizontal return-tubular boiler as usually built for pressures up to 150 lb. A single-riveted girth seam is sufficient, although a triple-riveted, butt joint is necessary for the longitudinal seams. It is partly for this reason that patches are so often of the familiar horse-shoe type, Fig. 1. This shape is used for patches close to the girth seam. There is no straight side seam, and, therefore, the boiler is not weakened to any extent, provided the patch is not large.

When a patch is put on the middle portion of a sheet the shape shown in Fig. 2 is used, and there is no straight side seam.

These two forms are used when the patches are comparatively small, but if the bulge is large, the side seams sometimes become as much as 3 or 4 ft. long. The side seams must necessarily be straight, and this portion of the boiler virtually becomes single riveted; the pressure allowed on the boiler must be reduced accordingly. The proper thing to do under such a condition is to cut out the sheet to a trifle above the fire line and put in a new section, riveted to the original side seam on one side and having a seam of the same design on the other side. While this does not weaken the boiler, it is an expensive repair, because of the large patch and the extra labor for chipping and riveting and the removal of more or less brickwork.



Boiler Patches

To illustrate the method of laying out a patch, it is assumed that the fire sheet of a 72-in. boiler ½ in. thick is bagged about half-way between the front head and the bridge-wall. There is a 10x15-in. manhole in the front head below the tubes, and to just remove all of the defective plate a circle 15 in. in diameter will have to be cut out.

The patch should be placed on the inside of the shell. This is not to avoid the probability of it blowing off, as is sometimes supposed; there is no danger of this, even though the patch were on the outside, the rivets being amply strong to prevent it. The reason is to avoid the formation of a pocket in which sediment can collect, with the attendant danger of burning the patch.

The bag is shown in Fig. 3 by the irregular lines, the

dotted line indicating the 15-in. circle it is necessary to cut out. The rivet holes must be punched or drilled around the outside of this circle, and it is customary to allow one and one-half times the diameter of the rivet from the edge of the plate to the center of the rivet hole. As this plate is ½ in. thick, ⅞-in. rivets will be used. This will bring the center of the rivet hole $1\frac{5}{16}$ in. outside of the 15-in. circle, making the diameter from center to center of the rivets 17⅝ in.

In the patch it is necessary to allow one and one-half times the diameter of the rivet, or $1\frac{5}{16}$ in. from the center of the rivet hole to the edge of the plate, making the total diameter of the patch 20¼ in. This is shown in Fig. 4.

This patch will not pass through the manhole, yet good practice demands that it be put on from the inside. The way to do this is to make both the patch and the opening in the boiler elliptical, as in the case of a manhead, and pass the patch through the opening. In doing this, the long axis is placed girthwise of the boiler so as to weaken the shell as little as possible. The long axis must be at least 20¼ in., say 20½ in. long, to allow the patch to enter easily. Adding one and one-half times the rivet diameter from the edge of the opening to the center of the rivet hole, and one and one-half times the rivet diameters again from the center of the rivet hole to the edge of the patch—a total of three rivet diameters to each end of the patch—makes the long axis 25½ in. long.

The opening in the boiler shell will be 15x20½ in., and the patch is 20¼x25½ in. It is passed to the inside of the boiler through the opening just as a manhead is passed through the manhole, then turned into position. and bolted in place while the riveting is being done.

There is an all too common practice of patching boilers as a result of bags. Probably 75 per cent. of the patches applied to boilers could have been avoided by properly setting the bulges back. This is not only cheaper than a patch, but is to be preferred, as it does not weaken the boiler and all trouble due to leakage and fire cracks is avoided.

There is a frequently expressed opinion that if a sheet is once bagged and set back, it is apt to bag again in the same spot. This contention is not supported by practice, as the metal is practically as thick as it was before it bagged, and would bulge again only when overheated, caused by another accumulation of sediment or grease. The original bag occurred at a point where sediment was deposited, and if more accumulates it will do so in the same spot and another bag will result, but not because the sheet has once been bagged and set back. This action is just as likely to occur on a patch as it is on a sheet which has been set back.

A troublesome feature in connection with patches is the formation of fire cracks extending from the rivet holes to the edge of the plate. They gradually grow worse, and open up until the leakage becomes such that it is necessary to remove the patch and put on a larger one. Although these cracks are by no means confined to patches, they are also prevalent around the edges of patches on the fire sheets, at the girth seams over the fire, and around the fire-door frames of some internally fired boilers. It is generally conceeded that they are caused by the cold air striking these seams when the fire-doors are opened, thus producing severe stresses. There are many boilers, however, operated under identical conditions in which there are no fire cracks.

It was generally thought that a double-riveted patch cannot be kept tight over the fire, but the writer is convinced that such a seam may be used year after year, and that all trouble from fire cracks may be avoided by putting the patch on properly. An extensive experience with boilers of all sizes and thickness of plate, is evidence that the trouble is due to the use of the drift pin. When the rivet holes do not come fair, and are forced into line with the drift pin, the metal is strained beyond its elastic limit and is under a severe initial strain with no elasticity to care for those of regular service; therefore leakage and cracks soon result.

The trouble is avoided by drilling all rivet holes in place rather than punching them, or punching them at least ¼ in. under size and then reaming them. The edges should be slightly chamfered to remove the burrs and minute cracks radiating from the hole A number of large patches have been put on in this way in plates up to $\frac{7}{16}$ in. thick and exposed to the direct action of the fire and they have held tight for years under regular operating conditions. This work costs considerable more than the usual method, but it is money well spent and will save dollars in repairs.

Pyro-Perolin Boiler-Cleaning Process

The Pyro-Perolin process for keeping boilers free of scale, consists of an apparatus which generates and combines various gases in such proportions that when they are ignited and the flame is applied to the scale, which has been previously treated with Perolin, the combination decomposes and disintegrates the scale, leaving the metal clean, even in inaccessible parts.

Cleaning a boiler by this process requires from one to three days, depending upon its size, condition and type. After it is cleaned a liquid protective film is applied to fill the pores of the metal and establish a smooth surface, to prevent scale-forming sediments adhering. This film is maintained and the boiler kept in a clean condition by feeding daily a small amount of Perolin metal treatment.

The manufacturer, The Perolin Co. of America, 1112 W. Thirty-seventh St., Chicago, Ill., guarantees to clean any type or size of boiler by its process and free it from scale in not more than four days, without damaging the boiler, the setting or the attachments. The boiler is subject to the inspection and approval of the boiler-insurance companies. The company also guarantees to protect the boiler metal against pitting, corrosion and galvanic action, regardless of the kind of water used.

Denatured Electricity—An interesting method of preventing the improper use of electric current has been devised by an Italian engineer. The practice of making especially low rates for current to be used in electric power, heating and cooking devices is becoming more and more general, but with the ordinary constant potential current it is difficult to detect the use of lights on circuits intended only for power and heating. This engineer advocates the use of special circuits on which the current is subject to extreme fluctuation of voltage at rapidly recurring intervals, which would make it practically impossible to use lamps, because of the flicker. As the current is not entirely interrupted and the normal voltage is almost instantly stored, the proper operation of power or heating apparatus is not interfered with and the rightful use of the circuits for their respective purposes is assured.

Editorials

The Indiana Boiler Law

We have before arisen to remark upon the carelessness with which statutes and ordinances are sometimes drawn. The present expostulation is the result of a reading of the Steam Boiler Inspection Law enacted by the General Assembly of the State of Indiana something over a year ago.

In section 8 it is decreed that:

> The bracing and staying of flat surfaces shall be so designed that seventy-five hundred (7500) pounds per sq.in. shall be the maximum pressure allowed.

Of course, the intent is that the maximum pressure allowed shall be such as will not stress the stays over 7500 pounds per square inch of cross-section, but that is not what the statute says.

In the same section occurs the following paragraph which we commend to the analytical scrutiny of our readers:

> All manholes shall be above the tubes in boilers fifty-four (54) inches, and above in diameter shall be placed in the top of the shell, and to be made of pressed steel.

Section 10 fixes the factor of safety of new "Indiana Standard" boilers at not less than five, with rivet holes punched at least one-eighth of an inch smaller in diameter than the rivet holes desired, and the rivet holes reamed out. "All boilers now in service of lapped longitudinal seam construction shall be allowed a factor (*all* boilers *a* factor) of safety as an examination of design and construction warrant, but not less than 5½." Boilers already built with butt-strapped longitudinal joints with two straps, may have factors of safety of not less than five. Boilers having longitudinal butt joints with but a single strap, will be treated the same as lapped-joint boilers. These factors of safety are all considerably high, and one can readily see where a manufacturer who has put in a boiler adapted to his work, with factors of safety in ordinary use before the passage of the law, will find himself out of tune with the department when it tries to reduce the allowable pressure anywhere from twenty to thirty per cent.

In the formula given in Section 24 for determining the safe working pressure for surfaces not self-supporting, with screwed stays riveted over, it is evident that the legislators or the printer have forgotten to put an exponent over the symbol for the thickness of the plate, for the pressure would vary as the square of and not directly as the thickness. As another example of loose English, this section concludes with the sentence "*All* curved surfaces not self-supporting shall be treated as *a* flat surface."

In Section 27 it is stipulated that "When stay-bolts are punched they shall be punched at least one-eighth inch less in diameter than the stay-bolt at the root of its thread." Stay-bolts are sometimes drilled, but the punching stipulation is evidently intended to apply to the plate and not to the bolt. The formula for determining the increased area of a stay which is indirectly applied, a diagonal brace, as compared with a direct or straight brace, is very badly mixed up in the reprints of the law which are distributed, but this may be due to the leaving out of subscripts on the part of the printer.

A statute which is to become a part of the written law of a state like Indiana is of sufficient importance to warrant revision and proofreading by somebody who knows the subject, before it is put on record.

*

Boiler Inspection during Construction

The closing sentence of the article "Cracked Headers on a Water-Tube Boiler," page 273, remarks the advantage of inspecting boilers while they are being built. Probably no one would dispute the statement that an inspection at that time is of more value than one made after the boiler is installed. Both are important, for a new boiler may have defects not evident before it has been in use for a season that will show up after pressure has been put upon it for a time. Quite as true is it that defects which would be almost impossible to detect after a boiler is erected would be plainly evident in a shop examination.

It may be almost too radical a proposition to put forth as a suggestion, but certainly there are attractive possibilities in the idea of a national law similar to the Food and Drugs Act, which would put the workmanship and materials used by boiler manufacturers under rigid inspection, in the interest of the public safety. The motive and the reason for such a law would be akin to those that occasioned the pure food law. Then shop inspection would not be as now, made only when the purchaser himself or his insurance company is particular enough to have it done.

This inspection service might go back farther than the boilermaker's shop and include inspection at the plate mill, even as the Government now inspects armor plate in the process of manufacture. It goes without saying that the inspectors would need to be experts by training, with actual experience in boiler and plate making, for the defects they would be expected to discover would be invisible to the eyes of a layman.

Until all states have boiler-inspection laws, such a national law as outlined, if it would not invade state's rights, would be of considerable protection. Boiler manufacturers, be they ever so desirous personally or as individual officers to avoid all chances of boiler accidents for the sake of humanity and their own good name, cannot control the conduct of their employees entirely. Wilful neglect, carelessness or ignorance on the part of an unwatched workman may easily culminate in a disaster. If outside inspection would avoid even a very few such accidents, it would be justified from every standpoint—the manufacturer's as well as the user's.

Using Examination Questions

The examination questions which appear on page 282 of this issue afford an opportunity for self-examination. Being questions actually used at Chicago in a recent test, they are thoroughly practical and should be answered in a lucid manner and not simply by reciting rules.

Probably, by much training, a parrot could be taught to repeat a formula or a rule correctly, but it would avail nothing. So with the engineer; the reasons for rules and formulas must be understood, as well as how and when to apply them before they are truly useful.

To get the real good out of answering or trying to answer these questions, the engineer must be impartial and honest with himself, answering them without help and then checking his answers by submitting them to others who are authorities or by looking up the answers in his books. Then he should mark his paper as impartially and even critically as he would were he an examiner and see how he likes the showing made.

Probably he will learn several things, among which will be that he did not have nearly the fund of information that he or his friends supposed, nor could he express creditably in writing what he did know in a general way; that the examiner was expected to know what was meant anyway, whether properly expressed or not; that the examiner actually did and generally does make liberal allowances—i.e., that the popular idea of an *upright* judge is one who *leans* considerably; that being human, he probably does lean to some extent in every case, etc. If properly conducted, such a self-examination will develop surprises and benefits unsuspected.

It is first rate to endeavor to impress others as favorably as possible, but it is best to be honest with one's self. It is told of an ancient warrior that he had for a motto on the front of his shield toward the enemy, "Be bold," but on the reverse side, for his own eyes, there were two additional words. "Be *not too* bold."

The Unusual Man

Recently an engineer traveled from Pittsburgh, Penn., to Bahia, Brazil, to do half an hour's work.

This engineer, William R. Sonricker, works for a Pittsburgh manufacturing concern that is installing some large refrigerating plants in South America, and this particular plant at Bahia would not work. Of course, the men on the construction job exhausted their resources to find and correct the defect, but they could not locate the cause of the trouble. So a cablegram was sent to the makers of the apparatus, and in response to it Sonricker was sent with all possible speed to the scene of the trouble. Upon his arrival, he located the difficulty, made the necessary adjustment and was ready to begin his return journey within half an hour.

It is fair to assume that a piece of apparatus designed for use so far away from the home shop as Bahia is from Pittsburgh would be of the simplest character possible. At least it would be designed in such a way as to avoid any complications. It is also reasonable to suppose that the men intrusted with the work of erecting the machine were familiar enough with it to correct any fault common to units of its type. The short time required by Sonricker to find the defect and apply the remedy shows that the fault was not great.

The feature of this incident which interests engineers is the reason why Sonricker was selected for this important mission to Bahia. It must have been because of his ability to find the right answer to any engineering problem that might be involved in the balk the plant had made. There were other mechanical engineers and refrigeration specialists already on the job, but they were not successful. Sonricker was peculiarly gifted as a trouble finder.

His knowledge of the machine that refused to run must be both comprehensive and microscopic; general, still specific in every detail. Not only so, but Sonricker must be more than a mere "mechanical" engineer; he must be a scientist in a sense—a close observer, an original thinker, a student of the principles and laws governing mechanical operations and apparatus, and be able to trace them with unerring accuracy back to their source and true cause. Knowledge, wide and deep, must be the equipment of the man who is intrusted with unusual missions. But further, there must be also the capacity to comprehend, to analyze, and to draw conclusions.

Men thus constituted and equipped can always command good compensation for their service, and their service is always in demand. And the best thing about it all is that the way to success in this line is no "royal road." It is open to every man on the same terms. Ambition, determination to achieve, energy, all wisely directed, constitute the terms.

Fusible Plugs

At a recent meeting of boiler inspectors, the value of fusible plugs for boilers was discussed, along with other questions. While the usefulness of the device was conceded, if kept in proper condition and frequently renewed, by most of those who discussed the question it was the opinion that fusible plugs, as used under ordinary conditions, are not reliable.

Among the rules recently issued by the Board of Boiler Rules of the State of Massachusetts the one relating to fusible plugs states that they must be filled with pure tin and that the least diameter shall not be less than one-half inch, except for working pressures over 175 lb. gage; when it is necessary to place a fusible plug in a tube, the least diameter of the fusible metal shall not be less than ⅜ in.

Thus the engineers of at least one state are required by law to use plugs of a certain fusible metal, and the minimum limit in sizes is also fixed, but nothing is found in the rules which compels a negligent engineer to renew fusible plugs at stated intervals, which would seem to be one of the main precautions to guard against their failure.

If the fusible metal always remained clean and free from coating, the necessity of frequent renewal would be eliminated, but with the ordinary feed water, deposits adhere to the surface of the plug, and in many instances have effectually prevented it from fusing.

If a fusible plug is not filled with the proper fusing metal, and if it is not kept clean, it becomes a menace and fails as a safeguard.

Engineers have an opportunity to note the action of safety plugs in their boilers, and undoubtedly have formed an opinion as to their value as a safety appliance. Are they or are they not to be depended upon?

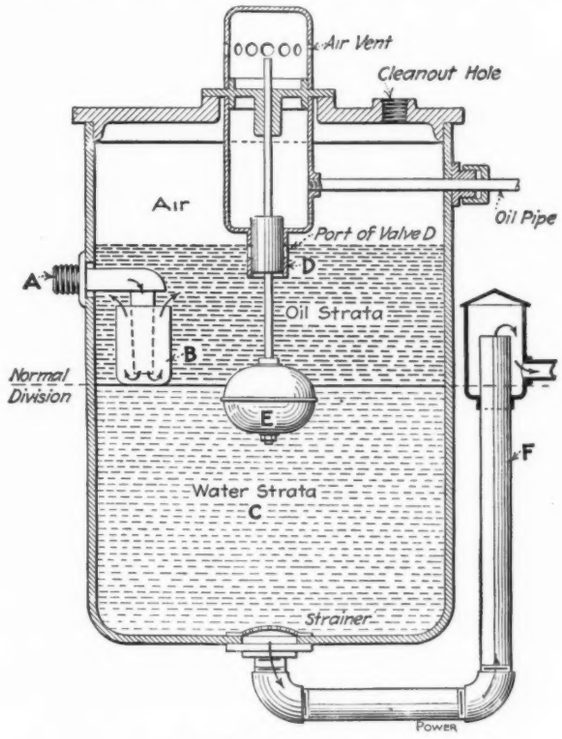
Correspondence

Gravity Oil Separator

On page 862, June 16, J. M. Long describes a float of the balanced differential type. It brings to my mind a piece of apparatus I built some years ago for separating oil and water.

It will automatically separate oil, air and water—in fact, anything which does not mix chemically and in which there is sufficient difference in the specific gravity to operate a float.

The condensate enters at *A* and is directed upward and into the strata of oil by the pipe *B*. The tank *C*



SECTION OF FILTER

is fitted with a float *E* and piston valve *D*, shown in a closed position. The float is so balanced that it will sink in oil and float in water, thus opening and closing the valve *D* to the atmosphere and the oil-vent pipe.

The tank *C* contains a certain amount of oil and water, and an increase of either will change the position of the float and cause the separator to act.

For instance, an increase in the water in the tank *C*, and column *F*, will cause it to overflow from *F* so long as it is supplied at *A*. With oil accumulating in tank *C*, thereby gradually lowering the level of the water, the float will operate the valve *D*, thereby allowing a small amount of oil to escape and to balance the machine again.

If any great amount of air is taken in at *A*, the operation would be practically the same. The levels would lower, due to the air volume above the oil increasing, and continue to lower until the valve *D* opened, and the air would escape.

No filters are used and the water is clean, due to the condensate entering the oil strata first and then falling by gravity, leaving the air and oil at the upper part of the apparatus.

EDWARD O. JOHNSON.

East Orange, N. J.

Boiler Capacity and CO_2

Relative to the inquiry of J. M. on page 145 of the July 28 issue, there will be no decrease in the capacity nor pressure of the boilers by slowing down the fan, providing the low percentage of CO_2 is due to too much air being forced through the fuel. The furnace temperature will be increased as there will be the same number of heat units contained in the lesser amount of furnace gas and hence more water will be evaporated. There is a definite relation between the amount of draft and the thickness or resistance of the fire. The thickness of the fire depends upon the character of the fuel and the size of the grate surface in relation to the capacity of the boiler; and the draft can be decreased to the proper minimum of excess air with an increase in economy.

If, however, the low percentage of CO_2 is due to air leaks in the setting or holes in the fuel bed, the CO_2 can be increased very little by reducing the draft and any attempt to reach a good percentage of CO_2 by this method will result in a decreased capacity and a drop of pressure; for when the draft has been regulated so as to burn the fuel with the minimum of excess air, the products of combustion being mixed with additional air above the grates, any further decrease in draft will result in incomplete combustion and the forming of CO instead of CO_2.

C. LESLIE BARNUM.

New Brighton, N. Y.

I find the altogether too general belief that a test for CO_2 is a test of flue gases. Undoubtedly a CO_2 test is better than none, but it does not tell the whole story. High CO_2 is taken to mean good combustion and low CO_2 bad. But of what value is high CO_2, if in getting it the draft is reduced to a point where CO passes up the stack unburned. Why not test for oxygen, CO_2 and CO, which would really amount to something.

The most economical point at which a boiler will work is usually not that at which it will evaporate the greatest amount of water; that is, by slowing down the fan, greater economy may be attained, but less coal can be burned.

Whether the boiler in this particular case would evaporate more water after slowing the fan is a question one can only attempt to answer from experience. I have tested boilers that developed 160 per cent. rating and the flue gases showed as low as 9 per cent. CO_2, and a

high percentage of oxygen with no CO. Upon taking off the blower the steam pressure dropped to 90 per cent. with practically no oxygen and 3 per cent. CO. If anything like this happens when the fan is slowed down the pressure will drop, but with a slight reduction of air, better conditions and greater evaporation will result.

J. A. COLTRIN.

Kewanee, Ill.

Flue-gas analysis alone is no gage of furnace efficiency. If 5 to 8 per cent. CO_2 is found on analysis of the flue gases, it may be due to a clinkered fire, too much draft with a thin fire, a fuel bed full of holes, or possibly air leakage through the setting. These causes for excess air must be detected, one by one, with the Orsat and draft gage. Then the draft necessary for various thicknesses of the fuel bed to obtain good combustion can be determined. The meager information given in the question will not enable one to determine whether the boilers will steam better or hold the required pressure.

H. A. Cox.

Middletown, N. Y.

Patching Boilers

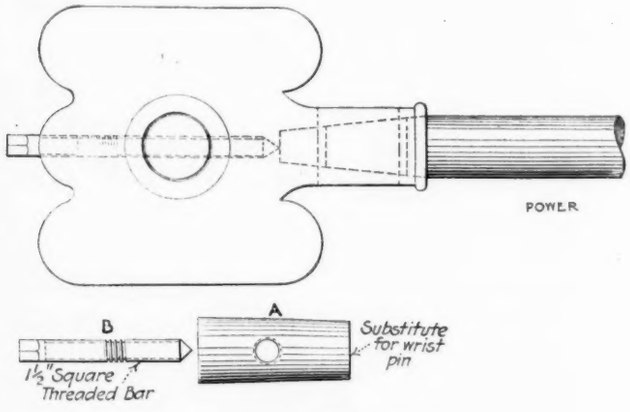
In reply to J. C. Hawkins' letter on page 25, July 7, I desire to say that the Hartford Steam Boiler Inspection & Insurance Co. had an article on that subject in its *Locomotive*, July, 1897, on page 97, and a more extensive article, July, 1908. The forms of patches are analyzed in those articles, and the form spoken of has been recommended by Hartford inspectors for some twenty years.

THOMAS E. SHEARS.

Denver, Colo.

Getting a Crosshead Off

Noting A. C. Waldron's method of removing the crosshead from the piston of large engines, on page 103, July 21, I think the following method is infinitely easier and more simple:



A JACK FOR CROSSHEADS

A pin *A* slightly smaller than the wristpin is drilled and tapped at right angles to its length to receive a 1½- or 2-in. bar or screw *B*, which is threaded and one end pointed to fit into the center in the piston rod, while the other end is squared for a wrench.

Insert pin *A* in the crosshead in place of the wristpin. Screw bar *B* into it until it engages the center in the end of the piston rod. Screw it up snug, tapping the crosshead lightly with a soft hammer at the same time, and the rod will yield readily.

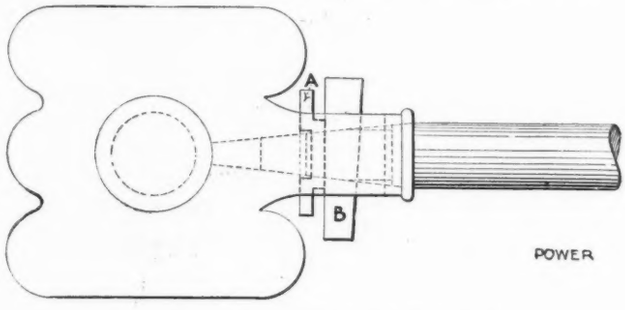
The size and length of the bar *B* is, of course, determined by the size and type of the engine. Obviously, the shorter it can be made, the better.

GEORGE G. LEE.

Ottawa, Ont., Canada.

With the larger sizes of engines having taper-fitted rods, the manufacturer formerly furnished a "drifting" set for removing the rod from the crosshead.

The illustration will interest any who may not have



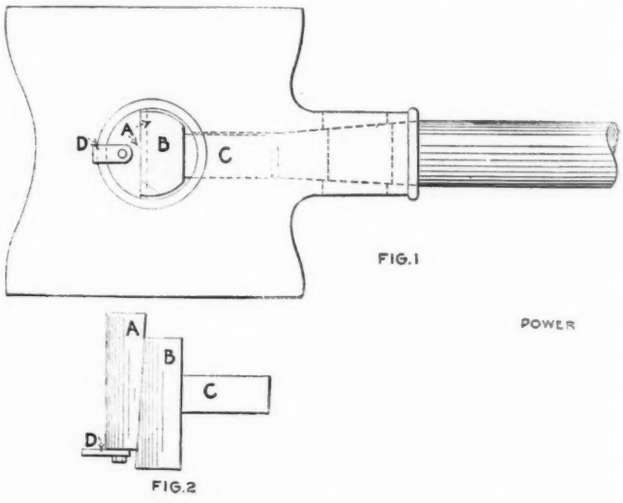
DRIFTING SET TO REMOVE CROSSHEAD

seen one. After removing the key, the offset piece *A* is inserted into the slot against the crosshead at the end next to the crank; a small piece, which is a little shorter than the rod's diameter, is used in the other end of the slot against the rod. By driving the key, the most stubborn set is loosened.

JOHN F. HURST.

Louisville, Ky.

Another method of removing a crosshead from a tapered piston rod is shown in the illustration. Part *A* is made tapered and is circular in shape on one side, to fit the eye, and flat on the other side. Part *B* is smaller



WEDGES FOR REMOVING CROSSHEAD

than the eye, and is also tapered, but is flat on opposite sides, forming a wedge. *B* is a mandrel of the right length to make up the distance between the end of the

piston rod and the wedge *B*. Stop *D* is to keep *A* from driving out. With the members assembled as shown, it is evident that a blow on wedge *B* will start the piston rod from the crosshead.

J. A. Lucas.

New York City.

Care of Commutators

I have not been bothered with commutator trouble for two years. Before that it was necessary to turn down the commutators every two or three months. They would run all right for a few weeks after turning, and then begin to heat again. I was in the habit of wiping them two or three times a day with engine oil, thinking that this was the proper thing. However, a light, slender carbon streak would begin to form at equal distances on three sides of the commutators on both of our 120-volt generators. From the width of a pencil, these grew little by little, until the whole commutator was black in five or six weeks.

These spots were sandpapered occasionally, and the black deposit wiped off to an appreciable extent, but always there remained the microscopic pitting on the surface of the bars, and three to four hours later it would be hot.

I usually repeated the process with as much diligence as possible, endeavoring for an effective cure, but the only way was to keep running until Saturday noon, when the repair squad would take the commutators over to the machine shop to be turned. A remedy has now been found in the following treatment:

Melt common wax in a pan, and put into this as much graphite as it will hold; leave it to cool and then cut it into cakes of about a cubic inch. The wax holds the graphite together. If the commutator heats, sandpaper it thoroughly; then apply this home-made cake. It will readily melt when held on the hot commutator. Come back several minutes after and touch it up again. Never use oil. If the commutator has a chocolate surface, it may not be necessary to sandpaper it, and the graphite composition may suffice.

Luke Marier.

Fall River, Mass.

Consulting Engineering Gratis

The editorial on this subject in the July 7 issue reminds me of a few instances when I was called on for help.

In one case a coal company had a 150-kw. generator driven by a simple engine which had operated satisfactorily for two years, but finally developed a serious knock. Upon arriving at the plant I was met by the superintendent, bookkeeper, store manager and many miners. All seemed to think the engine was "done" and ready for the scrap pile. After getting all the information I could it seemed to me that the trouble must be in the cylinder. I found that the follower had been bumping the head; one turn of the rod remedied the trouble. I received for my pay a kind "thank you ever so much until you are better paid."

On another occasion a mining company was notified that the air inspector would arrive, and as the air conditions were bad, the company attempted to improve matters by installing a small fan at one of the air courses, driving it with an old motor from the scrap pile. After all was apparently ready for the trial, the current was turned on; instead of the motor starting, the resistance in the starting box burned out. This happened twice, and then I was sent for.

I told the manager it would be impossible for me to leave my own plant at that time, but if necessary I would come after I got off duty. He insisted on it, and after riding a wheel six miles I arrived at the mines. The trouble was found and remedied quickly.

With a smile on his face, the manager stepped to one side out of the draft of the fan, took from his vest pocket a cigar, of which he had a good supply, lit it—and kept the rest in his pocket. After satisfying himself that all was ready for the air inspector, and without asking me if I had made arrangements for staying over until morning, or even finding a place for me to sleep, he turned in the direction of his bungalow and soon disappeared in the darkness.

Such experiences have taught me how to deal with people who want help. Now, when I am called for in an emergency, there is always an understanding at the start as to whether it is for business, pastime or for "In God we trust."

W. H. Corbin.

Sharples, W. Va.

Fastening Ball on Rod End

The thread was stripped from a Buckeye valve-gear and the ball on the end of the cutoff valve rod came off. The rod end did not go through the ball, so I filed the shoulder back for an eighth of an inch, so that the rod would extend through; put the ball on and riveted the rod end until the ball was fast; it has never come loose since. The valve was easily adjusted by shortening the eccentric rod.

Herbert Holroyd.

Philadelphia, Penn.

Hot Motor Bearings

One of the bearings on a 30-hp. motor always became very warm during a day's run, but no reason could be found for this as there always was plenty of oil in the oil well; moreover, it was renewed often. The bearings were of ring-oiled type. One day the bearing became warmer than usual and an investigation showed that the oil ring was not turning. The bearing was then taken apart and it was found that the inside of the oil ring, where it comes in contact with the shaft, was very smooth due to wear from long use. This made it impossible for the ring to turn with the shaft. By roughing the inside of the ring with a coarse file the trouble was cured.

I believe this bearing always ran warm because the oil ring did not turn at times so as to bring oil on top of the shaft, when the bearing would run dry. Again the oil ring would get into a position so that it would turn for a short time, then stop again. This same trouble will also occur where the inside of the ring has worn out of round from long use, when it will not turn freely with the shaft at times and must be started again by means of a stick through the oil-well hole.

In another instance, two bearings of the single-ring-oiler type on a large motor ran hot. Upon investigating, it was found that the rings did not turn at all and could not be made to turn with a stick through the oil-well cover. The bearings were then taken apart and it was found that the oil was of a sticky nature. Upon inquiring of the operator as to what oil he used, it developed that it had been taken out of a ten-gallon oil can standing near the motor. This was found to contain steel-cable dressing. Due to the bearings being hot, the oil rings were baked to the sides of the slot in the top bearing.

H. A. JAHNKE.

Milwaukee, Wis.

Examination Questions

The accompanying questions were asked in an examination held June 13, 1914, for the position of engineer-custodian, class E, group D, Board of Education, Chicago, Ill. Some people used to think that school engineers were janitors and scrubwomen, but the standard is improving, due to efforts to bring into the service the best class of engineers. The method pursued is a good one.

In the past, the examinations have been so easy that from 50 to 75 per cent. would pass, but I dare say that in this examination only about 10 per cent. of the 300 applicants will attain the eligible register. These high requirements will bring into the service men who have thorough engineering knowledge, though not necessarily a college education:

QUESTIONS

1. Name and discuss fully three ways in which the formation of scale in boilers is detrimental to the economical operation of a steam plant.

2. A certain boiler evaporates 3000 lb. of water per hr. at atmospheric pressure from a feed-water temperature of 160 deg. F., burning 500 lb. of coal in the furnace. If the coal is 80 per cent. combustible, what is the equivalent evaporation from and at 212 deg. per pound of combustible?

3. In example (2) above, (a) what was the boiler horsepower developed, and (b) if the coal used contained 12,100 B.t.u., what was the combined efficiency of boiler and furnace?

4. The shell of a tubular boiler 60 in. in diameter by 16 ft. long is $\frac{5}{16}$ in. thick; efficiency of joint, 81 per cent.; tensile strength of steel, 60,000 lb. per sq.in. Assume what you would consider the proper factor of safety and calculate the safe working pressure on this boiler and the proper size of lever safety valve for use at the calculated pressure.

5. A simple engine running 180 r.p.m. has a piston 10-in. diameter by 12-in. stroke; piston rod 1½ in. in diameter; m.e.p. 35 lb. per sq.in. If the mechanical efficiency of the engine is 90 per cent., what brake horsepower is the engine developing?

6. Define the meaning of the terms watt, ampere, volt, kilowatt. What is meant by a ground, on an electric-lighting system? What is the gage of the smallest wire that can be used in an interior electric-lighting system? What is the maximum load in watts that should be put on one electric-lighting circuit? How many horsepower are equivalent to one kilowatt?

7. (a) What is the difference between a simple and duplex steam pump, and name the relative advantages of each? (b) How many strokes of a simple pump with piston 5-in. diameter by 10-in. stroke will it require to fill a circular tank 4 ft. in diameter by 12 ft. high, allowing 20 per cent. for slippage?

8. (a) How many pounds of steam at atmospheric pressure will be condensed in a cast-iron indirect radiator in heating 25,000 cu.ft. of air from 15 deg. to 120 deg. F.? (b) Define "relative humidity." How is relative humidity affected by increase in temperature? What is meant by "dew point?"

9. A classroom contains 48 pupils. How many cubic feet of fresh air should be delivered to this room per hour to provide proper ventilation? What is the maximum velocity and maximum temperature at which air should enter the classroom through registers? What is the maximum percentage of CO_2 permissible in the atmosphere of a classroom?

10. Between what temperature limits should a classroom be kept? How long before opening for the school session should the classroom temperature be up to requirements?

11. Describe fully the construction of some type of thermostat with which you are familiar and which operates by means of compressed air, and describe how the thermostatic system in a school building automatically maintains the classroom temperature within the prescribed limits, when the plenum, single-duct blast system is used for heating and ventilating. Illustrate.

ARITHMETIC

1. (a) Multiply $15\frac{1}{9}$ by $6\frac{3}{8}$.
   (b) Divide 101.6688 by 2.36.

2. Compute the total pressure and pounds per square inch on the bottom of a cylindrical vessel 6 in. in diameter by 3 ft. high filled with a liquid which weighs 56 lb. per sq.ft.

3. The specific heat of cast iron is 0.13. How many heat units will a bar of cast iron weighing 30 lb. give up in cooling from 850 deg. to 60 deg. F.?

4. One cubic foot of steam at 70-lb. pressure weighs 0.195 lb. Allowing a steam velocity of 5000 ft. per min., what diameter of pipe will be required to supply 6500 lb. of steam per hour at a gage pressure of 70 lb. per sq.in.?

5. If the coefficient of friction is 23, how many horsepower will be required to draw a weight 3600 lb. up an incline at the rate of 55 ft. per min., if the incline rises 1 in. per ft.?

REPORT

Assume that you were in charge of a steam-heating plant consisting of three tubular boilers such as are used in school buildings, and it was found that you were burning too much coal. Write a report explaining how you would proceed to investigate the cause of the excessive coal consumption. Confine your investigation to the boiler room. Write a report of 150 words.

EXPERIENCE

What experience have you had as an operating engineer?

What experience have you had in the following lines? (a) Plumbing. (b) Steam fitting. (c) Electric work.

A. E. CHRISTOPHERSEN.

Chicago, Ill.

Inquiries of General Interest

Allowance for Frictional Resistance of Boiler Plates—In calculating the resistance of riveted joints of boilers, why is not the resistance of friction between the plates taken into consideration?

L. M.

The resistance due to friction between the plates may vary from 0 to a small percentage of the shearing strength of the rivets and no allowance can be made for such resistance because of its uncertainty.

Vent and Waste Trap on Open Heater—What is the purpose of a vent or vapor pipe, and also of an S-trap, on an open heater?

F. B.

A vent pipe connecting with the atmosphere is used to prevent the steam space from becoming air bound and also to prevent formation of a vacuum, which would endanger the shell of the heater to the collapsing pressure of the atmosphere. A running or "S" form of waste trap is used on the overflow to prevent steam from escaping to the sewer or other point of discharge of the overflow.

Siphonage Between Connected Boilers—When two boilers having their water lines at different levels are connected into the same steam line, is there any tendency for water to be siphoned over from one boiler to the other?

A. F. L.

With ordinary boiler connections there would be no siphonage of water from one boiler to the other, but if the feed connections of the boilers are connected together and the check valve of the boiler of higher water level leaks, then water would back up from the boiler of higher water level to that of lower water level.

Renewing Firebrick Lining—In putting an entirely new lining of firebrick under a horizontal-tubular boiler which is supported by brackets resting on the side walls, is it advisable to rebuild the side walls?

W. N. J.

The necessity for renewing the side walls would depend upon their condition and the manner in which they have been incorporated with the lining. Ordinarily side walls are built to support the boiler independently of the firebrick lining and the lining may be renewed without impairing the safety of the side walls.

Superiority of Flanged Over Screwed Fittings—In steam mains what are the advantages of flanged elbows and tees over screwed fittings?

C. J.

Besides the greater facility with which flanged joints may be made up or detached the fittings are not subjected to the bursting strain of making up tapered screw joints, which in screwed fittings are likely to be set up so hard as to leave little or no strength to resist a bursting pressure or to resist such stresses of leverage as are exerted on the fitting by expansion and contraction of different parts of the line.

Formula for V-Notch Weir—When the head is measured in inches, what is the formula for flow of water in cubic feet per minute over a right-angle V-notch weir?

J. R. P.

The formula is:

$$Q = h^2 \times \sqrt{h} \times 0.305$$

where

h = The head in inches measured vertically from the still water above the weir to the vertex of the notch;

and

Q = The number of cubic feet flowing per minute.

Formula for Weight of Flywheel—What is the formula for the weight of the rims of flywheels for Corliss engines?

F. W. A.

Where 480 ft. per min. is the lowest probable piston speed the weight for the rims of flywheels of Corliss engines of ordinary duty is given by the empirical formula:

$$W = 700{,}000\ d^2\ s \div D^2\ R^2,$$

in which

W = Weight of rim in pounds;
d = Diameter of cylinder in inches;
s = Stroke in inches;
D = Diameter of wheel in feet;
R = Revolutions per minute.

Flow Through Gate Valve—How can the amount of condensing water which is being discharged through a gate valve be determined from the number of turns of the handwheel?

C. A. H.

On account of the uncertainty of the amount of opening and variable coefficient of discharge for different openings, the discharge capacity of the valve should be calibrated by tank or weir measurements for different positions of the valve and for the different pressures employed on each side of the valve. The results of such a calibration can be arranged in the form of a table or chart by reference to which the discharge taking place under a given set of conditions could be readily determined.

Atmospheric Pressure at Bottom of a Shaft—What would be the pressure of the atmosphere at the bottom of a shaft which is sunk from sea level to a depth of 1000 ft.?

W. A. D.

The pressure of the atmosphere increases with the depth of shafts equal to about 1 in. rise in the barometer for each 900 ft. increase in depth. Assuming the pressure of the atmosphere at the top of the shaft to be 14.7 lb. per sq.in., then as 1 in. rise in the barometer would be equivalent to an increase of 0.491 lb. per sq.in., the pressure at a depth of 1000 ft. would be

$$14.7 + \left[\frac{1000}{900} \times 0.491\right] = 15.24\dot{6},$$ or about 15¼ lb. per sq.in.

Power Required for Centrifugal Pump—What horsepower would be required of a motor to drive a centrifugal pump which has a rated capacity of 260 gal. of water per minute discharging against a total head of 120 ft. with an efficiency of 52 per cent.?

S. B. R.

Taking the weight of 1 gal. of water as 8⅓ lb. then to discharge 260 gal. per minute against a head of 120 ft. with an efficiency of 52 per cent. would require

$$\frac{260 \times 8\frac{1}{3} \times 120}{0.52} = 500{,}000 \text{ ft.-lb. of work per minute.}$$

Hence the power developed by the motor would have to be 500,000 ÷ 33,000, or 15.15 hp.

Pipe Bending—How can pipes be bent without caving or flattening them?

J. G. M.

The commonest method of preventing flattening or caving from bending is to first fill the pipe with sand or pulverized rosin firmly tamped and held in place with a plug at each end of the pipe Caving-in occurs from too much concentration of bending force, hence any method of bending should be performed by a succession of grips taken close together. The smaller sizes of steel and iron pipe can be bent cold to quite a small radius of curvature and without first filling them by taking a sufficiently large number of short grips and using a cover pipe or a stiff mandrel within the pipe to prevent the occurrence of bends too far from the grips. Short bends of uniform curvature are made by passing the pipe between rolls grooved on their periphery to fit nearly half way around the pipe, employing two rollers on the outside and one on the inside of the curvature of the bend in the same way that three rolls are used for curving a boiler sheet. Another method of bending largely used for smaller sizes of pipe, and pipe of softer materials, is by bending or "wiping" the pipe over forms that will give the desired curvature.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXIII

Last Lesson's Answers

101. The three factors that determine the quantity of heat in a body are (a) the specific heat of the body. (Note: *the specific heat of a body is the amount of heat required to raise one pound of the substance one degree Fahrenheit*); (b) the weight of the body and (c) the range of temperature above a given reference point. As an example find the amount of heat in one hundred pounds of water above 32 deg. F. if the temperature of the water is 62 deg. F. The specific heat of water is unity—the weight is 100 lb.—and the range of temperature above 32 deg. F. is 62 — 32 = 30 deg.; hence the total heat in the water above 32 deg. F. is $1 \times 100 \times 30 = 3000$ B.t.u.

As a general rule the heat in a body is measured with reference to the temperature at which the body changes from a solid to a liquid, or a gas.

102. *Temperature expresses the degree or intensity of the heat in a body* and is measured by the rise of a column of mercury placed in a glass tube of fine uniform bore. On the Fahrenheit scale the freezing point of water is located at 32 deg. and the boiling point at 212 deg. Between the freezing and boiling points there are 180 divisions (212 — 180) on the scale. Hence, a change of one degree Fahrenheit means that the mercury rises a distance equal to $^1/_{180}$ of the distance between the freezing and the boiling points.

103. The quantity of heat required to change the temperature of one pound of water one degree Fahrenheit decreases as the temperature of the water increases. This is due to the fact that the density of the water decreases with an increase of temperature.

104. The total heat liberated per hour by the complete combustion of 1000 lb. of the fuel is

$$12{,}000 \times 1000 = 12{,}000{,}000 \text{ B.t.u.}$$

and the heat liberated per minute

$$\frac{12{,}000{,}000}{60} = 200{,}000 \; B.t.u.$$

As one horsepower equals 42.3 B.t.u., the horsepower equivalent to the heat set free is

$$\frac{200{,}000}{42.3} = 4728 \; hp.$$

The equivalent boiler-horsepower is

$$\frac{4728}{13} = 363 \; boiler \; hp.$$

Under actual working conditions, only about 80 per cent. of the above figure could be secured, assuming that a water-tube boiler was used, so that the probable boiler-horsepower would be about

$$0.8 \times 363 = 290 \; boiler\text{-}hp.$$

105. From the conditions of the problem the heat absorbed by the water equals $0.80 \times 12{,}000{,}000$ or 9,600,000 B.t.u. per hour. To evaporate one pound of water requires 1050 B.t.u., hence 9,600,000 B.t.u. will evaporate

$$\frac{9{,}600{,}000}{1050} = 9143 \; lb$$

Under working conditions, approximately 30 lb. of water must be evaporated to produce a boiler-horsepower, hence the boiler-horsepower is

$$\frac{9143}{30} = 304 \; b.hp.$$

which agrees very closely with the answer given in problem 104.

The Inclined Plane

In Lesson XII, the term "machine" was defined and several types were discussed. Some additional forms will now be discussed with relation to the work done by the machine.

Frequently, in construction work, heavy objects such as parts of machines, etc., must be lifted when, with the apparatus available, it is impracticable to raise the object directly. In such instances, the *inclined plane* is used. A common application of it is in the loading or unloading of heavy machinery from freight cars. A long incline is built in front of the car and the piece of machinery placed upon a skid which in turn rests upon the inclined

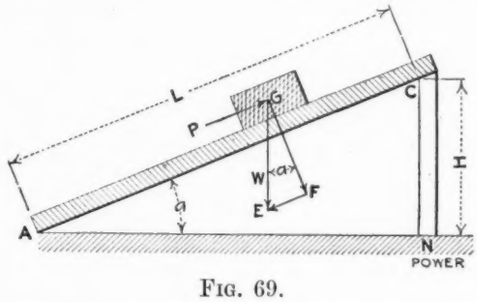


Fig. 69.

plane. By the aid of the proper tackle the part can be drawn up to the car.

In the following discussion two general cases will be considered:

(1) The plane perfectly smooth—thus eliminating friction.

(2) The plane rough—thus including friction.

Case I. Smooth Plane—Friction Neglected

Let AC, Fig. 69, represent the given plane, inclined at an angle of a degrees with the horizontal and assume the body G to be acted upon by a force P parallel to the plane. The weight W may be resolved into two components—one parallel to the plane and the other at right angles to the plane. Since in this case friction is to be neglected, the only force tending to oppose the force P will be the component EF of the weight W down the plane. By construction, the angle EGF = the angle CAN = the angle a. The component $EF = W \times \sin a$, hence the force P must equal the component EF or $P = W \times \sin a$.

Let H = the height of the plane, and L = the length of the plane. Since $\sin a = \frac{CN}{AC} = \frac{H}{L}$ it follows that

$$P = W \times \sin a = \frac{W \times H}{L} \qquad (59)$$

Example—What force P will be required to move 1000 lb. on a plane which rises 1 foot in 10. Here the

$$\sin a = \frac{H}{L} = \frac{1}{10}$$

and the force

$$P = \frac{W \times H}{L} = \frac{1000 \times 1}{10} = 100 \text{ lb.}$$

This shows that a force of 100 lb. acting parallel to the plane is capable of moving 1000 lb. up the plane.

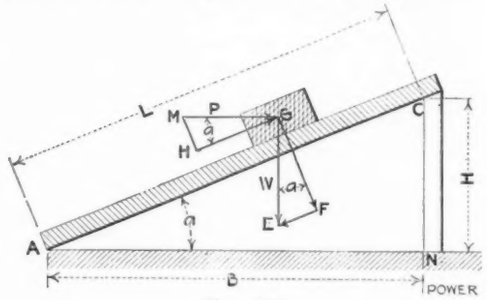


FIG. 70.

Fig. 70 shows a case where the force P is horizontal instead of being parallel to the plane. Here the only effective force tending to move the body up the plane will be the component of the force P parallel to the plane. By construction, it is readily seen that the angle HGM is equal to the angle CAN = the angle a. The component of the force P parallel to the plane $= GH = MG \cos a = P \cos a$. The force acting down the plane is, as before

$$W \times \sin a$$

For equilibrium to exist, the forces acting up the plane must equal the forces acting down the plane or

$$P \cos a = W \sin a \text{ or,}$$

$$P = W \frac{\sin a}{\cos a} = W \tan a \qquad (60)$$

Let B = the length of the base of the plane. Then,

since $$\sin a = \frac{CN}{AC} = \frac{H}{L}$$

and $$\cos a = \frac{AN}{AC} = \frac{B}{L}$$

it follows that $P = W \frac{\sin a}{\cos a} = W \frac{HL}{LB}$ or

$$P = W \frac{H}{B} \qquad (61)$$

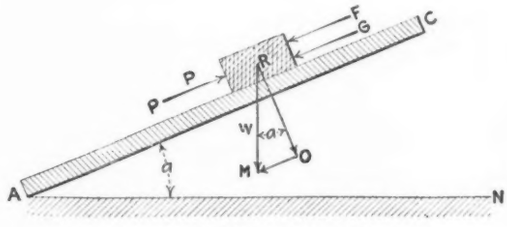


FIG. 71.

Example—What force P will be required to move 1000 lb. up a plane whose base angle is 5 deg. 50 min.? From equation (60)

$P = W \tan a = 1000 \tan 5 \text{ deg. } 50 \text{ min.} = 1000 \times 0.102$
$= 102 \text{ lb.}$

This demonstrates that the horizontal force required to move the body up the plane is greater than the force parallel to the plane.

CASE II—PLANE ROUGH—FRICTION INCLUDED

When a body is on the point of moving up the plane, both the force of gravity and the force of friction tend to oppose the motion, as both these forces are acting down the plane. On the other hand, if the body is on the point of moving down the plane the force of gravity will tend to help this motion, but the force of friction will act up the plane as *friction always acts opposite to the direction of motion.* Hence between certain limits the body will remain at rest on the plane.

In Fig. 71, let the force P act parallel to and up the plane. Then the force of friction F down the plane will equal the coefficient of friction f times the normal reaction RO (see lesson XIV), and the force of gravity G, acting down the plane is equal to $W \sin a$. For equilibrium to exist $P = F + G$,

but $F = f \times RO = f \times W \cos a$, therefore,

$$P = fW \cos a + W \sin a \qquad (62)$$

The force P required to put the body in motion up the plane will be greater than that given by equation (62) by an amount equal to the force required to overcome the inertia of the body. When the force P has the value given in equation (62), the body will just be on the point of starting up the plane.

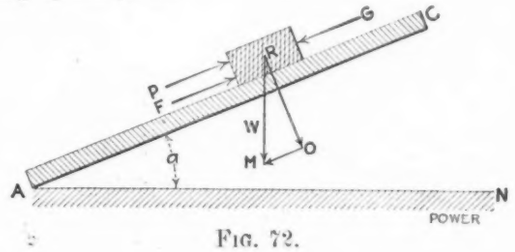


FIG. 72.

In Fig. 72, let the force P act up the plane and assume the body to be on the point of moving down the plane. In this case for equilibrium to exist, the force of gravity acting down the plane must be balanced by the force of friction and the force P acting up the plane or

$$G = P + F, \text{ or } P = G - F$$

but $$F = f \times W \cos a$$

and $$G = W \sin a,$$ therefore,

$$P = W \sin a - f W \cos a \qquad (63)$$

For the body to remain at rest on the plane, the value of the force P must lie between the limits of W ($f \cos a + \sin a$) and W ($\sin a - f \cos a$).

STUDY QUESTIONS

106. In Fig. 69, what force P will be required to hold a skid carrying a steam pump at rest on the plane AC? Neglect the force of friction. The plane rises 1 in 12 and the weight of the skid and pump is 1600 lb.

107. With the same data as given in 106, find the horizontal force P required to hold the skid on the plane.

108. If the coefficient of friction between the skid and the plane is 0.18, find the least force P which will prevent the skid from sliding down the plane.

109. Find the force P parallel to the plane which will just start motion of the skid up the plane. Assume the same data as in the previous problem.

110. Under what conditions will it be necessary for the force P to act down the plane to set the body in motion. See Fig. 72.

Cast-Iron Boiler Explodes

On the evening of July 10, a cast-iron boiler exploded in the Langston & Son machine shop, at Camden, N. J. It appears that steam from this boiler was used during that day to test some brass cylinders.

At the time the boiler failed the pressure was 30 lb. and the pop safety valve inactive. Fortunately the watchman had just left the room, and no one was injured, although the boiler was completely wrecked and several windows and doors broken. Who removed the safety from the safety valve? Another call for inspection and competent supervision over boilers of all classes by the state.

Cyclone Wrecks Henderson, Ky., Plant

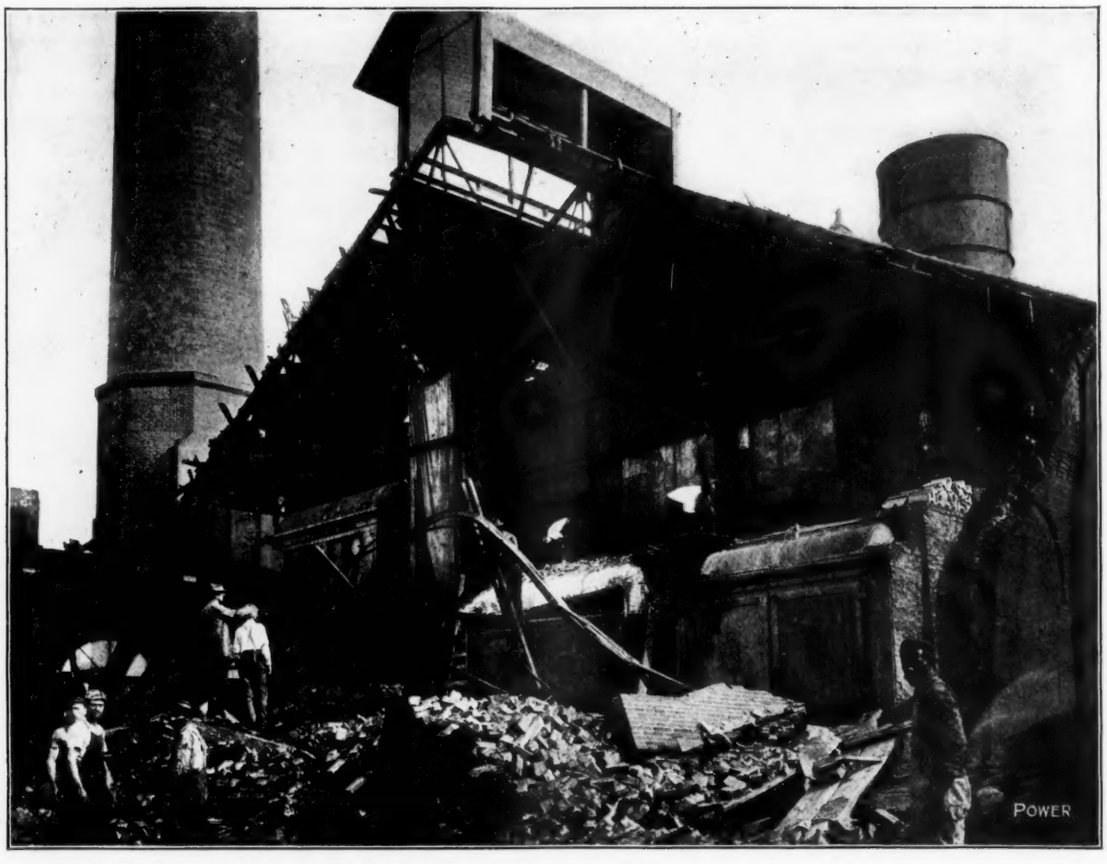
A cyclone damaged the municipal electric-light plant at Henderson, Ky., July 16. Herewith is a view of the wrecked boiler room which was cut in half. The falling bricks, steel and timbers stripped the fronts of the boilers of all the small pipes, water-gage columns and steam gages.

The two 400-hp. Atlas boilers, on the right, were in service at the time, and the 400-hp. Stirling boiler, on the left, is a new one being erected. If the cyclone had occurred 30 minutes sooner it is likely it would have caught about 15 men at work on the installation of the new boiler; they had just quit and left the boiler room. The one fireman in the boiler room at the time had just stepped in between the Atlas boilers to regulate the feed water when the roof came in on him, but he climbed out uninjured over about 8 ft. of wreckage.

The accident happened about 6 p.m., and as it continued to rain and blow quite hard for the rest of the night the repair work was not started until the next morning. The traction cars and interurban lines were in operation about five o'clock that afternoon and the city service in the business part was put on at 7 p.m. next day, being out about 25 hours.

The new 225x11-ft. brick chimney, just recently built, escaped injury. The boiler room will be rebuilt with a steel-frame construction and enlarged to a sufficient size to accommodate five 400-hp. boilers. A great many wires were down all over town on account of trees blowing down on them, but only a few poles were broken.

We are indebted to L. P. Hite, the superintendent of the plant for the above information.



Cyclone-Wrecked Plant at Henderson, Ky.

Program for World's First International Engineering Congress

The Panama-Pacific International Exposition, San Francisco, from Sept. 20-25, 1915, will be the meeting-place of the largest body of distinguished engineers that ever gathered in any one place. The assemblage, to be known as the International Engineering Congress, will be presided over by Col. George W. Goethals, who has accepted the office of honorary president.

In response to over 80,000 invitations, thousands of civil, mining, mechanical, electrical, marine and military engineers and naval architects, from nearly forty different nations and representing hundreds of affiliated bodies, have declared their intention of attending the congress. The sessions will be held in the new million-dollar Auditorium now being constructed in the civic center of San Francisco, the main hall of which has a seating capacity of ten thousand. Section meetings will be held in the eleven minor halls in the great convention building.

The International Engineering Congress is to be conducted under the auspices of five national associations, viz., the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers, assisted by a committee of eighteen distinguished California engineers.

The vast scope of the congress is indicated by the fact that it will be divided into eleven groups of sub-congresses, the reports of which it is calculated will fill eleven large volumes. Chief among these branches will be that dealing exhaustively with the problem worked out in the construc-

tion of the big Isthmian ditch, and the influence of the canal on world commerce, commercial trade routes and general transportation problems. Colonel Goethals will have charge of the presentation of all canal topics, and his papers and discussion will carry with them the authority and value of official reports. Aside from general engineering topics, the section devoted to the canal will be treated under 22 heads, as follows:

(1) Col. Goethals' general report; (2) Dry excavation of the Panama Canal, by Col. Goethals; (3) Dredging the canal (4) Terminal works, dry docks and wharves of the canal; (5) Meteorology and hydrology of the zone; (8) Designs of locks, dams and regulating works; (9) Methods of construction of same on the Atlantic side; (10) Same on the Pacific side; (11) Designs of locks, walls and valves; (12) Spillways; (13) Gates of the canal; (14) Electrical and mechanical installation; (15) Emergency dams above locks; (16) Municipal engineering and domestic water supply in the zone; (17) Reconstruction of the Panama Railroad; (18) Aids to navigation of the canal; (19) Geology of the canal zone; (20) The working force of the canal; (21) Sanitation in the zone; (22) Purchase of supplies for the canal.

Following Colonel Goethals' personal reports, each of these topics will be treated by the heads of departments or other attachés who were responsible for that part of the canal construction. These addresses and papers will constitute practically the official technical record of the most gigantic and fascinating engineering feat of all time. It will be published, forming the only printed record of its kind, and for this compilation, interesting to the layman no less than to engineers, credit is due to the exposition congress. Programs for the other ten sections of the congress are in course of preparation.

Subscriptions are being received daily by the local organizations which will act as hosts for this great body, a large proportion of these being from foreign bodies and foreign engineers. The most noted experts of the world in all departments of engineering work have availed themselves of this opportunity not only to visit the exposition, but to pass through the canal en route.

Marion Station Coal-Crane Wreck

A high wind blew down the 150-ton gantry crane at the Marion power station of the Public Service Electric Co. of New Jersey, on July 23. The crane, which was parallel with the station, was blown along its track for a distance of about 300 ft., falling over on a yard locomotive. Eight wheels on one side were locked by brakes. When the storm broke, the crane was standing at the western end of the track on a coal dock on the Hackensack River. The wind started the crane, which acquired a high rate of speed along the level track, falling at the opposite end of the track. The tracks upon which the locomotive was standing were pushed about 2 ft. into the ground.

The crane had been in service 10 years. It handled coal from barges to storage piles and from the piles to the hoppers in the buildings.

The wreck of the crane is shown in the accompanying views. The span of the crane was 150 ft. 2¼ in., the height 43 ft. 1 in. to the upper chord, and the wheel base 27 ft. long. The principal operating features of the crane are shown in Fig. 1 of the tower nearer the station.

The cross structure of the crane carries a belt, which can be supplied with coal from the belt conveyor running parallel with the station. The coal is conveyed on the crane belt to about the center where it is tipped, falling to storage piles. When it is desired to return the coal from the piles to the station, the clam-shell bucket places the coal in the hopper over which it is suspended (Fig. 1). After being crushed it is carried up to the belt on the stationary structure,

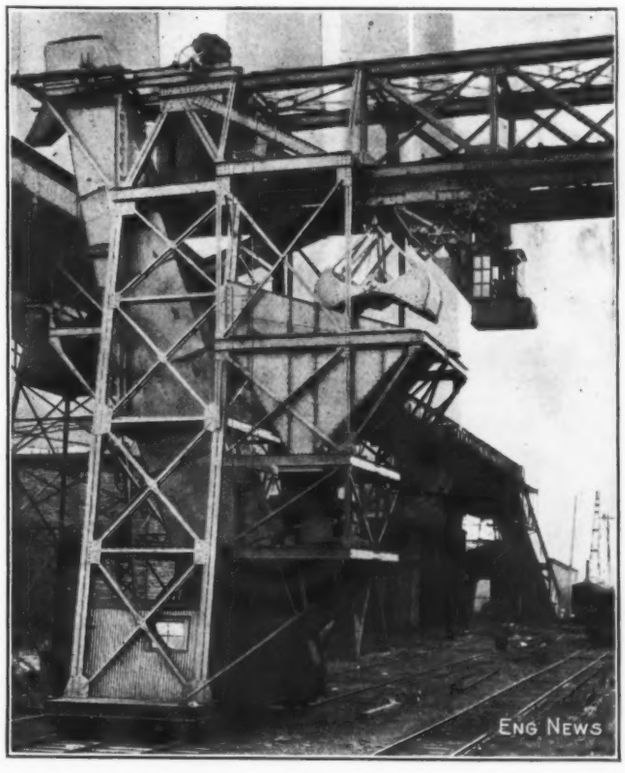


FIG. 1. ONE END OF CRANE BEFORE ACCIDENT

running parallel to the travel of the crane. The track on which the crane travels is 300 ft. long and is not provided with bumpers at the end.

The high wind carried the crane from one end of its track to the other, and when the crane reached the end of the track the forward trucks went off to the ground, a distance of about 8 ft., where they sank. The crane, of course, fell over in the direction of its motion,

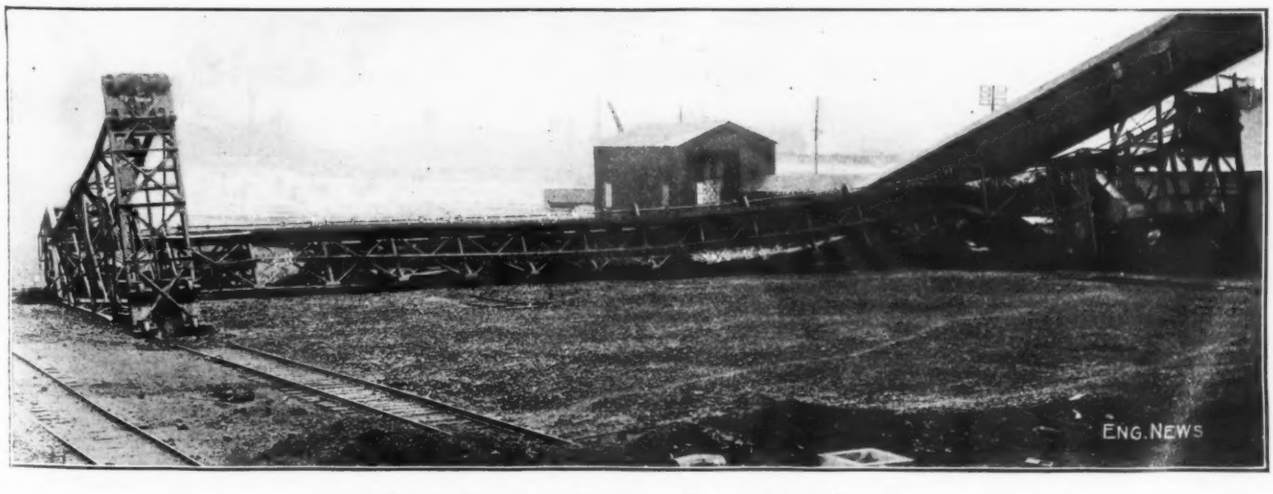


FIG. 2. GENERAL VIEW OF OVERTURNED CRANE

FIG. 3. (LEFT) POSITION OF YARD LOCOMOTIVE BENEATH WRECK. (RIGHT) DETAILS OF DERAILMENT
(The structural excellence of a locomotive boiler is exhibited in a remarkable manner in the left-hand view.)

not only wrecking itself but also a yard locomotive. The position of the crane after its fall is shown in Fig. 2. Fig. 3 shows the wreckage of the crane and the locomotive. The small views at the right of Fig. 3 show the manner in which the forward wheels sank into the ground after derailment. The bearing cap of one is shown to be broken, leaving the wheel nearly buried.

The crane is damaged beyond repair and it is expected that a new one will be erected in its place. The damage is estimated at $50,000. The crane was furnished ten years ago by the Robins Conveying Belt Co., New York City. It was braked by a locking device on a reduction shaft from the driving motor. It is claimed by the electric company that all driving wheels were locked in this manner at the time of the accident.—Engineering News.

BUSINESS ITEMS

The Champion Fibre Co., Canton, N. C., recently placed an order with Yarnall-Waring Co., Philadelphia, Penn., for 20 Simplex Blow-Off Valves, as a result of a trial of two valves since last October.

John Simmons Co., 110 Centre St., New York, has taken over the manufacturing and selling rights of the Klein Boiler Circulator "Kebec" and has established a new department, under the direction of Paul M. Klein.

The Graton & Knight Mfg. Co., Worcester, Mass., has recently opened a branch office at 301 Magazine St., New Orleans, La., where it will carry a complete line of leather belting, lace leather, belt dressing and cement.

Every engineer who registered at the booth of the Engineers' Appliance Co., of Cleveland, Ohio, at the recent craftsmen's convention, should write direct to the company for one of their new catalogs. In some way the register was lost, and for that reason the company has been unable to send the books as agreed.

The 1915 Friction Clutch Catalog of the Moore & White Co., Philadelphia, Penn., will be ready for distribution on Sept. 1. The new book is an instructive as well as interesting treatise on friction clutches, and should be in the hands of everyone interested in the subject. A copy will be sent on request.

The Whitlock Coil Pipe Co., Hartford, Conn., has opened an office in Chicago, under the management of Richard S. Bull, at 431 South Dearborn St. The Chicago office will handle the company's full line of feed-water heaters, hot water-storage and service heaters, high-pressure pipe bends, flanged joints, etc., for Chicago and surrounding territory.

A most interesting bulletin has just been issued by the National Tube Co., Frick Building, Pittsburgh, Pa., on the "Relative Corrosion of Iron and Steel as Found in Service." It contains an article by William H. Walker, Ph.D., on this subject, and also contains three other valuable articles on the subject of corrosion, namely, "Plain Facts About 'National' Pipe for the Plumber and Steamfitter," "Relative Merits of Wrought-Iron and Steel Pipe," and "Further Discussion of the Relative Merits of Wrought-Iron and Steel Pipe," by F. N. Speller, metallurgical engineer, National Tube Co. The bulletin is called Bulletin 10C. It is sent on request.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Central Gas & Electric Co., Geneva, N. Y., will issue $83,500 in bonds, the proceeds to be used for the improvement and extension of the electric-light department. A. V. Wainwright is Gen. Mgr.

Bids will be received until Aug. 26, by the Board of Freeholders, Newark, N. J., for the installation of a 300-hp. water-tube boiler an dauxiliary apparatus for the Overbrook Hospital. Runyon & Carey, Newark, are the Consult. Engrs.

The City Council, Cumberland, Md., contemplates purchasing a 300-kw. generator for the municipal electric-light plant. Joseph S. Scriver is Water and Light Comr.

SOUTHERN STATES

Press reports state that the Southern Power Co., Charlotte, N. C., contemplates establishing a steam-turbine plant to cost about $1,000,000. C. I. Burkholder, Charlotte, is Mgr.

The citizens of Bay Minette, Ala., have voted $5000 in bonds for the construction of a municipal electric-light plant. Edgar B. Kay, Tuscaloosa, is Consult. Engr.

The City of Knoxville, Tenn., contemplates installing two 350-hp. water-tube boilers and two 10,000,000-gal. vertical triple-expansion engines. Dabney H. Maury is Hydraulic Engr.

CENTRAL STATES

The Board of Bond Trustees of the Bowling Green State Normal College, Bowling Green, Ohio, has approved plans prepared for the construction of a power plant for the college.

Charles Brossman, Union Trust Bldg., Indianapolis, Ind., has been commissioned by the City Council of Huntington, Ind., to prepare plans and supervise the reconstruction of the municipal electric-light plant, for which bonds have been voted.

The Indiana Steel & Wire Co., Muncie, Ind., will install another boiler unit in its plant. The unit will be either two 250-hp., two 300-hp., one 500-hp. or one 600-hp. single-unit water-tube boiler.

According to press reports, bids will soon be received by the City Council, Elmwood, Ill., for the construction of a municipal electric-light plant.

The Superior Water, Light & Power Co., Superior, Wis., will issue $250,000 in stock. Improvements and addition to the plant will be made. W. H. Winslow is Gen. Mgr.

WEST OF THE MISSISSIPPI

Plans are being prepared for the installation of a municipal electric-light plant at Sergeant Bluff, Iowa. The estimated cost is $10,000.

Bids will be received about Sept. 15 for the construction of a municipal electric-light plant at Adams, Neb. The equipment will include two generators, a two-panel switchboard, six transformers, etc. Johnson & Johnson, Falls City, Neb., are the Engrs-in-Charge.

The Havre Electric Co., Havre, Mont., contemplates making improvements to its plant to cost $50,000. F. W. McCarthy is Mgr.